



# The American Journal of Surgery

*Editor:* THURSTON SCOTT WELTON, M.D., NEW YORK

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NEW SERIES, VOLUME LXXVIII

JULY TO DECEMBER

1949

PUBLISHED MONTHLY BY

THE YORKE PUBLISHING COMPANY, INC.

49 WEST 45TH STREET, NEW YORK 19, N. Y.

MCMXLIX



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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-eighth Year of Publication

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VOL. LXXVIII

JULY, 1949

NUMBER ONE

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## Editorial

### A SIMPLE QUESTIONNAIRE FOR THE TAKING OF HISTORIES IN CASES OF CANCER

THE taking of medical histories in hospitals and clinics is a duty usually assigned to junior members of the house staff and constitutes a part of their progressive post-graduate hospital training. Under certain circumstances this task may even be relegated to a medical secretary. These observations apply to general hospitals and clinics as well as to the more highly specialized institutes. The present report is concerned solely with cancer hospitals and tumor clinics.

In the course of his post-graduate hospital training the intern, resident or fellow probably does not remain long in a position where his duties include the taking of histories. As he reaches the senior positions on the house staff this traditionally somewhat onerous task is usually passed on down to successive junior members of the house staff. The result is that clinical histories in cancer cases, as they accumulate over a period of years, will have been taken by a succession of post-graduate trainees at a time when they are just beginning their hospital experience. The junior house officer, therefore, can hardly be expected to exercise reasonably good discrimination or to have attained sufficient insight regarding the type of questions which are essential in cancer cases. At any rate, without some specific direc-

tives the clinical records will hardly be complete or uniformly arranged. Although in some of the cases the histories may be excellent, in others the information will be so meager or so confused as to vitiate the over-all value of the greater mass of recorded data.

In highly specialized institutions such as cancer hospitals or tumor clinics one solution to the problem of the clinical history of the present illness would be to provide a set of instructions in the form of a questionnaire which would always be before the intern when he is actually taking the history. It seems reasonable to make such a questionnaire simple and concise so that even though it might not include all the details which must be recorded in a given case, it would provide a logical sequence of questions which would fully bring out in chronologic order the more important features in the history of the present illness and suggest the directions in which further inquiries might be made.

The following is a questionnaire which, if consistently and routinely employed, would tend to bring out the more significant points in a cancer history, many of which might otherwise be omitted. It is to be noted that all questions begin with and often include the specific interrogations, "when," "what" and "how."

After recording the family history and past medical history according to the usual routine, use the following questions for the present illness:

1. WHEN did you first notice anything wrong or abnormal in connection with your present complaint?

If the patient gives an indefinite answer such as "about 3 months," recheck by asking the exact month. Record the exact month and year in the history.

2. WHAT SYMPTOM or difficulty did you notice first and what other symptoms followed and when?

It is important to ascertain the exact first symptom. Some discretion may be used in recording the character and order of symptoms. Some are obviously entirely irrelevant.

The following are the most significant symptoms (not necessarily the only ones) in the various anatomic forms of cancer. Their presence or absence should always be recorded.

Skin and subcutaneous tissues: The lesion itself—ulcer—swelling.

Mouth: The lesion itself—pain—cervical metastasis.

Nasopharynx: Cervical metastasis—unilateral deafness or tinnitus.

Oral and hypopharynx and extrinsic larynx: Dysphagia—cervical metastasis. Intrinsic larynx (vocal cords): Hoarseness.

Esophagus: Dysphagia.

Lung: Cough—hemoptysis—pain.

Breast: Tumor mass—deformity—nipple bleeding.

Stomach and small intestine: Indigestion—anorexia—vomiting—weight loss.

G. U. system: Hematuria—dysuria—frequency.

Gyn. viscera: Bleeding—discharge—pelvic pain.

Large intestine and rectum: Change of bowel habit—bleeding.

Leukemia and other blood dyscrasias:

Fatiguability—bleeding tendency.

3. WHAT DID YOU FIRST THINK caused your trouble?

The patients' opinion as to the cause of the growth is always of interest even though illogical.

4. WHEN AND HOW LONG AFTER the first symptom DID YOU CONSULT YOUR DOCTOR OR DENTIST? (Include cultists and irregular practitioners.)

Always record the names and addresses of all doctors or dentists consulted. If only the last name and the street address (without the number) can be obtained, that information is nevertheless of value.

5. WHAT EXAMINATION did the doctor make? Did he make a rectal or vaginal examination? Did he use an endoscope or throat mirror? Did he take a specimen for examination or make a blood test? What treatment did he give or prescribe for you?

It is essential to record the method of examination and subsequent management of a cancer case in order to fix responsibility for delay in diagnosis and treatment.

6. WHAT ADVICE did the doctor or dentist give you in regard to the necessity for further examination either by himself or by some other doctor? Did he tell you the name of your disease?

The attitude of the first physician or dentist consulted in regard to advice and treatment is an excellent indication of their tentative diagnoses.

7. WHAT DID YOU DO in carrying out the doctor's advice?

Continue interrogating the patient in regard to subsequent doctors consulted, treatment, operations, etc.

8. WHO finally REFERRED YOU to this Hospital or clinic and when was this advice first given?

Attempts should be made to obtain accurate and specific information as to the name and address of the referring doctor or clinic. These parties often have biopsy slides, records of treatment, and furthermore expect to be informed of the patient's admission and progress under treatment.

Under Question 2, it should be noted that specific symptoms are listed in the order of their importance and would apply particularly to each of the major anatomic sites in which cancer is likely to occur. These symptoms are of such importance that they should be recorded both when

present and when absent. This list was obtained by checking with a number of surgeons and internists, each of whom had had many years of experience in one or another anatomic form of cancer. Each was asked to name the three most important symptoms in the order of their significance in a particular clinical field. It is to be noted that in certain diseases such as cancer of the intrinsic larynx and esophagus, a single symptom (hoarseness and

dysphagia, respectively) stands out as being so constant and unique that no other symptoms need be listed under this particular heading.

In the Memorial Hospital this questionnaire has been found so useful that it is printed on the reverse side of the clinical history sheet so that it may be before the questioner at all times when taking and recording histories.

HAYES MARTIN, M.D.



After recording the family history and past medical history according to the usual routine, use the following questions for the present illness:

1. WHEN did you first notice anything wrong or abnormal in connection with your present complaint?

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Breast: Tumor mass—deformity—nipple bleeding.

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Gyn. viscera: Bleeding—discharge—pelvic pain.

Large intestine and rectum: Change of bowel habit—bleeding.

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HAYES MARTIN, M.D.



The anterior complex consisted of two to five nerve trunks which descended onto the left half of the esophagus from behind the left inferior pulmonary vein. These trunks split and regrouped according to no consistent pattern as the trunks passed caudad. Often one or two of the trunks ran caudad on the lateral or even posterolateral aspect of the esophagus before curving toward its anterior aspect in the lower half. One or two other trunks of the complex curved to the posterolateral aspect of the esophagus in the upper half to two-thirds of the dissected area, finally crossing the posterior aspect of the esophagus to join the posterior complex.

The trunks of the anterior complex usually fused into one or more anterior gastric nerves at or just above the level of the esophageal hiatus in the diaphragm.

The same general pattern of branching and anastomosing trunks characterized the posterior complex, some trunks of which often continued caudad on the right lateral and right anterolateral aspects of the esophagus. There were two to five trunks on the right side as on the left. The whole sweep of left-sided trunks anteriorward, and of right-sided trunks posteriorward, is the result of the 90 degree embryologic rotation of the stomach on its axis. (Fig. 1.)

From the branching and anastomosing trunks of the anterior and posterior complexes, finer branches arose at intervals to penetrate the parietal pericardium and pleura and the muscular coats of the esophagus at intervals to innervate its intrinsic structures. It is highly significant that finer trunks of the anterior and posterior complexes in places ran for distances of up to 3 cm. between the longitudinal muscle fibers of the esophagus and emerged more caudally to anastomose with other trunks, this finding occurring in one or more instances in 76 per cent of specimens. This finding again would be of relatively minor academic interest were it not for the fact that in eleven instances (22 per cent) a fine trunk disappeared beneath the longitudinal muscle layer of the anterior esoph-

agus above the diaphragm and reappeared from beneath the same muscle layer on the anterior aspect of the stomach. (Figs. 6, 8, 10 and 12.) This phenomenon has also been observed by Abbott.<sup>40</sup>

The textbooks of anatomy point out that the anterior and posterior gastric nerves consist of fibers from both right and left vagi. A variable number of nerve bundles passed from the anteriormost trunks of the upper half or two-thirds of the right or posterior complex, caudad and toward the left on the anterior aspect of the esophagus to join the various branches or trunks of the anterior complex and contribute to the anterior gastric nerves, but without standard pattern. This occurred in forty-eight of the fifty specimens (96 per cent) examined in the series. It consequently became impossible often to determine how far to the right the limit of the anterior complex lay, or how far to the left the anterior limit of the right or posterior complex extended. A fusion zone of trunks containing neurons from both right and left vagus nerves widened downward, often absorbing or being absorbed into the anterior complex and giving rise to one or more anterior gastric nerves while contributing often also to the posterior gastric nerve.

Invariably one or more trunks passed from the upper third or half of the anterior complex down the left lateral and posterolateral aspects of the esophagus to join the posterior complex in its caudal two-thirds, often the branch with the largest diameter joining the posterior gastric nerve just above the level of the esophageal hiatus. (Figs. 6 and 8.) Again, a fusion zone existed posteriorly between anterior and posterior complexes, here absorbing or being absorbed into the right or posterior complex and giving rise to the posterior gastric nerve(s).

Classically the anterior complex is said to be amalgamated into a single anterior gastric nerve at a variable distance cephalad of the esophageal hiatus, and a similar phenomenon is reputed to occur posteriorly. The anterior gastric nerve is

said to pass through the hiatus on the left anterolateral aspect of the esophagus and the posterior on the right posterolateral aspect thereof. From the statistical data presented it is evident that the posterior trunks passed through the hiatus fused into one or two trunks which generally occupied a more constant position in relation to the esophagus than did the anterior.

Subdiaphragmatically, as McCrea<sup>19,41</sup> and Latarjet<sup>13</sup> observed, the distribution of the anterior and posterior gastric nerves was less variable than at any level below the bifurcation of the trachea. The anterior gastric nerve(s) divided very close to the esophageal hiatus into three to six branches, those of smaller diameter running toward the greater curvature of the stomach at right angles to the axis of the stomach, branching and to a variable degree regrouping into finer rami which eventually penetrated the muscular coats of the stomach wall beyond which they could not be followed macroscopically. This has been described as the left group of branches by McCrea and as the anterior gastric plexus by Sobotta<sup>42</sup> when the anastomoses between the branches are plentiful. Consistently there was a branch of the anterior gastric nerve running caudad along the lesser curvature with descending branches of the left gastric artery to the incisura. From this branch, which Latarjet has called the principal anterior nerve of the lesser curvature, many smaller rami arose to run perpendicularly toward the greater curvature, and to this nerve may be added anastomosing rami from the left group of branches. One or more branches of the anterior gastric nerve were found between the leaves of the lesser omentum running toward the hilum of the liver. (Figs. 5, 6 and 7.) These branches and a possible third nerve paralleling the principal nerve of the lesser curvature on its left side constitute the right branches described by McCrea.

The posterior gastric nerve(s) passed caudad, often 1 to 1.5 cm. to the right of the lesser curvature of the stomach, the largest terminal branch accompanying the

left gastric artery to end in the celiac ganglion. Branches of the posterior gastric nerve(s) arose from 1 to 2 cm. below the esophageal hiatus and 2 to 3 cm. from the celiac ganglion. Similar to those anteriorly, the branches ran approximately perpendic-

TABLE I  
CLASSIFICATION OF THE PATTERN OF THE VAGUS INNER-  
VATION OF THE STOMACH AT THE ESOPHAGEAL  
HIATUS (FIFTY CONSECUTIVE CADAVERS)

Group	No.	Per cent
i. Single anterior and posterior trunks...	7	14
ii. One anterior and two posterior trunks...	4	8
iii. Two anterior and one posterior trunks...	13	26
iv. Two anterior and two posterior trunks...	7	14
v. Three or more anterior and one posterior trunks.....	10	20
vi. Three or more anterior and two or more posterior trunks.....	9	18

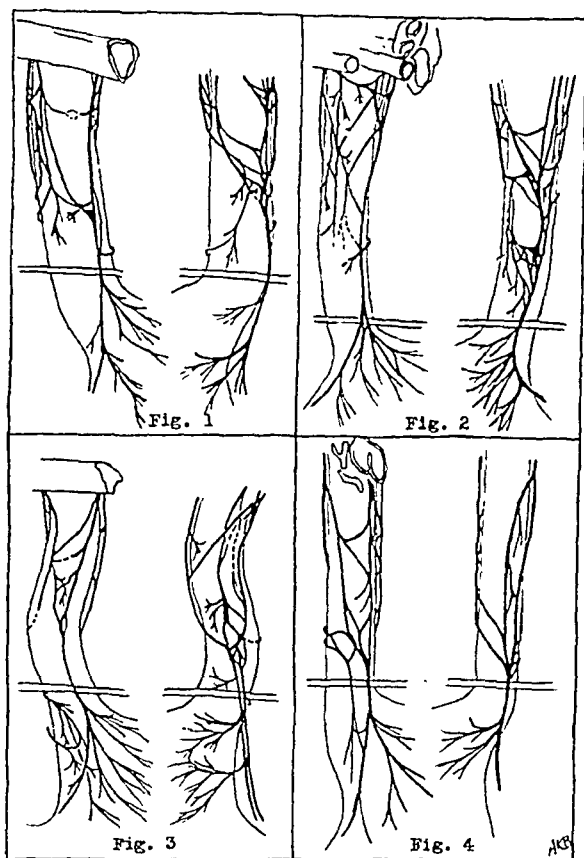
ularly to the trunk onto the posterior aspect of the stomach, divided and to a variable extent regrouped into branches of increasing number and decreasing caliber eventually diving into the musculature of the stomach. Where the anastomoses were common, this was similarly called a posterior gastric plexus. Still other branches of the posterior gastric nerve followed the lesser curvature toward the incisura angularis (the principal posterior nerve of the lesser curvature of Latarjet) and in turn gave off smaller branches running perpendicular to the axis of the stomach onto its posterior aspect. In nine instances branches of the posterior gastric nerve(s) arising at or below the esophageal hiatus passed onto the anterior aspect of the stomach, usually anastomosing macroscopically (contrary to the statements of Latarjet) with branches of the anterior gastric nerve. (Figs. 3, 9, 11 and 12.) This was commonly found by McCrea.

In reviewing the individual dissections of this series, it appeared that classification was feasible on the basis of the complexity and number of gastric nerve trunks on the esophagus at and just above the esophageal hiatus. More than 3 cm. above the hiatus



the branching and anastomosing of the nerves of the esophagus lay in such divergent patterns as could be described only in the general terms above.

*Group I.* The simplest pattern found was that illustrated in Figures 1 and 2.



FIGS. 1 to 4. The left sketch in each figure represents the anterior aspect of the lower esophagus from the lung root to the esophageal hiatus and the anterior aspect of the stomach down to the incisura. The right sketch represents the posterior aspect. Dotted lines indicate intramuscular course of the vagus nerve fibers. (1) Single anterior and posterior gastric nerves at the esophageal hiatus (Group I); (2) high branching of the anterior gastric nerve (Group I); (3) single anterior and double posterior gastric nerves at the esophageal hiatus (Group II), with two posterior branches curving onto the anterior aspect of the stomach; (4) double anterior and single posterior gastric nerves (Group III). The right anterior trunk is about one-third the diameter of the left.

Here the trunks of the anterior complex united into a single anterior gastric nerve 1 to 3 cm. above the esophageal hiatus in six instances and at 7 cm. above in one instance. The trunks of the posterior complex united into a single nerve in all seven

specimens somewhere from the hiatus to a level 2 cm. above it.

Three of the seven specimens in this group showed the anterior gastric nerve beginning to divide into its terminal branches just above the level of the diaphragm. (Fig. 2.) In all seven instances the anterior gastric nerve passed through the esophageal hiatus between the anterior midline of the esophagus and its left border, and the posterior nerve passed through between the right border of the esophagus and a point one-third of the way across its posterior aspect toward the left border. The configurations of anterior and posterior gastric nerves in this small group are similar to the ninety-two described by Bradley and his associates<sup>1</sup> and to thirty described by Chamberlin and Winship.<sup>43</sup>

*Group II.* A somewhat more complex pattern obtained in four specimens in which one anterior and two posterior gastric nerves passed through the esophageal hiatus. (Fig. 3.) The anterior trunks again occupied the same relative position to the esophagus as in the group just described, and both posterior trunks passed through the hiatus just posterior to the right border of the esophagus, the two trunks being not more than 0.3 cm. apart.

Two specimens showed these posterior trunks reuniting into a single trunk 1.5 cm. below the esophageal hiatus. In the other specimens wherein the trunks remained separate, the right trunk of the pair sent a communicating branch arising below the diaphragm onto the anterior aspect of the stomach. (Fig. 3.)

*Group III.* In thirteen specimens, a quarter of the total number of dissections, two gastric nerves passed through the esophageal hiatus anteriorly and one posteriorly. This occurred in five of the thirteen cases illustrated in the paper of Miller and Davis.<sup>3</sup>

In nine of the thirteen cadavers of this series the larger of the two anterior trunks was on the left, in eight being situated as in Group I on the left anterior half of the esophagus (Fig. 4), and in one within 0.4 cm. of the right border of the esophagus in anteroposterior projection. In

these nine specimens the two trunks were separated by as much as 1.0 cm. or as little as 0.2 cm. at the level of the esophageal hiatus. In one specimen of the subgroup of eight the smaller anterior nerve ran through the hiatus deep to the longitudinal muscle layer of the esophagus, the nerve penetrating to this position 1.5 cm. above the diaphragm and promptly sending two communicating branches above the diaphragm, both deep also to the longitudinal coat, to join the larger anterior nerve. (Fig. 6.) In three of the four remaining specimens, the two anterior trunks were of equal size and not more than 0.3 cm. apart. (Fig. 5.)

Usually the two anterior gastric nerves anastomosed on the anterior aspect of the stomach within 1.5 cm. of the undersurface of the diaphragm. Communicating rami linked the two anterior gastric nerves on the anterior surface of the lower esophagus within 3.5 cm. of the upper surface of the diaphragm. Consequently the smaller branch would be identified if the larger trunk were found and dissection of the trunk carried above or below the diaphragm for the distances indicated.

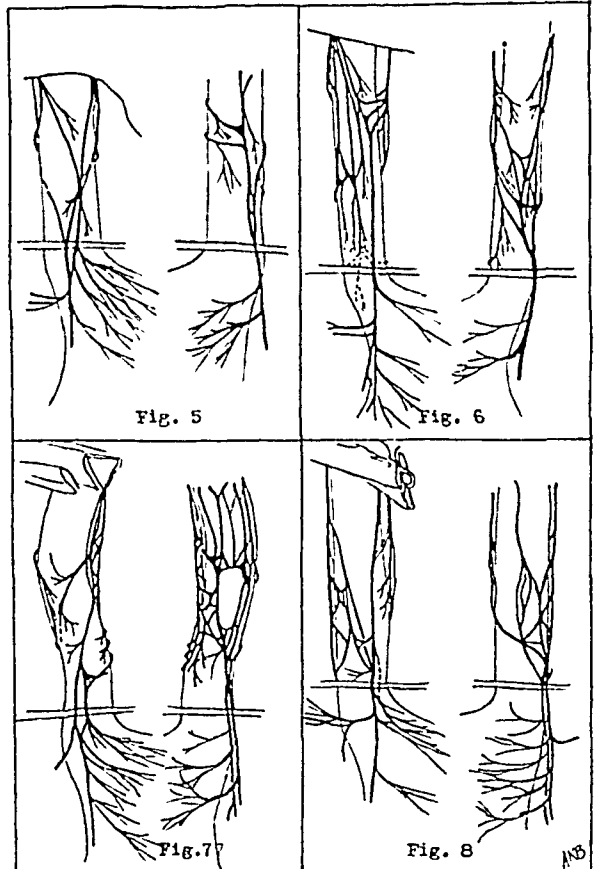
In three specimens the right-sided anterior trunk seemed to be composed exclusively of fibers arising from the lateral or anterolateral aspect of the right or posterior complex and passing downward constantly more to the left to converge with the larger anterior gastric nerve within 0.2 cm. of the undersurface of the diaphragm.

*Group IV.* Seven dissections disclosed a fourth possible pattern with two gastric nerves passing through the esophageal hiatus anteriorly and two posteriorly. (Figs. 7 and 8.)

The two posterior trunks occupied the position behind the right border of the esophagus and showed the proximity to each other already noted in Group II. Some of the anterior trunks, as in Group III, arose largely from the right or posterior complex and joined the other anterior gastric nerve subdiaphragmatically, after passing through the hiatus somewhere between the anterior midline of the esophagus and its projected right border. This phenomenon merely represented a caudal displacement of some of the communicating trunks from the anterior limits of the posterior or right complex joining the left or anterior complex.

Of the seven dissections, three showed the smaller anterior trunk running through the hiatus deep to the longitudinal muscle layer in the fashion already described. (Fig. 8.)

*Group V.* Of equal complexity with Group IV was a group of ten cadavers pos-



Figs. 5 to 8. The left sketch in each figure represents the anterior aspect of the lower esophagus from the lung root to the esophageal hiatus and the anterior aspect of the stomach down to the incisura. The right sketch represents the posterior aspect. Dotted lines indicate intramuscular course of the vagus nerve fibers. (5) Double anterior and single posterior gastric nerves (Group III), the anterior trunks of equal caliber; (6) double anterior and single posterior gastric nerves (Group III), one anterior nerve intramuscular in position; (7) double anterior and posterior gastric nerves (Group IV); (8) double anterior and posterior gastric nerves (Group IV), one anterior nerve intramuscular in position.

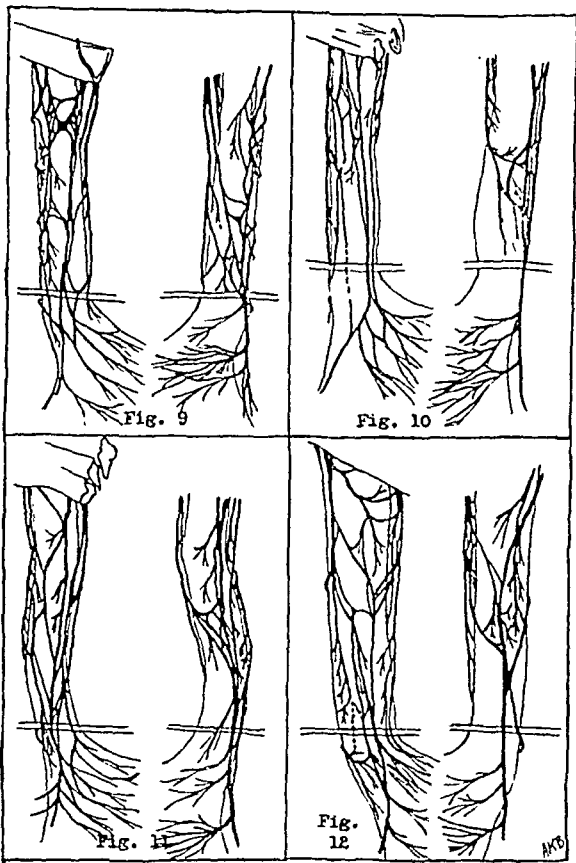
sessing three or more anterior gastric nerves passing through the esophageal hiatus and one posteriorly. (Figs. 9 and 10.)

Usually one anterior trunk possessed a diameter two to three times that of the others. The finer anterior gastric nerves passed through the hiatus both to the right and left of this

larger trunk all the way across the anterior aspect of the esophagus. Within 2.5 cm. below the diaphragm these trunks anastomosed with each other, giving origin to the usual left and right branches found on the anterior aspect of the stomach: In three specimens one or two

more nerve trunks posteriorly. (Figs. 11 and 12.)

Four of the nine dissections showed one or more anterior nerve trunks to be submuscular. (Fig. 12.) It would be arbitrary in these nine



FIGS. 9 to 12. The left sketch in each figure represents the anterior aspect of the lower esophagus from the lung root to the esophageal hiatus and the anterior aspect of the stomach down to the incisura. The right sketch represents the posterior aspect. Dotted lines indicate intramuscular course of the vagus nerve fibers. (9) Three or more anterior gastric nerves and a single posterior nerve (Group v); (10) three or more anterior gastric nerves and a single posterior nerve (Group v), one of the anterior nerves intramuscular in position; (11) three or more anterior gastric nerves and two or more posterior nerves (Group vi); (12) three or more anterior gastric nerves and two posterior nerves (Group vi), one of the anterior nerves intramuscular in position.

anterior trunks ran through the hiatus sub-muscularly. (Fig. 10.)

Group VI. The most complex configurations of all, nine in number, consisted in three or more nerve trunks passing through the hiatus anteriorly and two or

TABLE II  
PER CENT OF SUBJECTS SHOWING SINGLE ANTERIOR AND POSTERIOR GASTRIC NERVES AT THE ESOPHAGEAL HIATUS ACCORDING TO RECENT ANATOMIC STUDIES

Author	No. of Subjects	Material	No. with Only Two Gastric Nerves	
			No.	Per cent
Bradley and associates.	100	Autopsy	92	(92)
Miller and Davis.....	13	Autopsy	5	(38)
Chamberlin and Winshin.....	50	Embalmed	30	(60)
Boyd.....	50	Embalmed	7	(14)

specimens to set any caudal limit on the anterior complex branching which continued onto the anterior aspect to the stomach; the esophageal plexus had no caudal fusion into one or two anterior gastric nerves but branching and anastomosing continued until the terminal branches to the stomach were given off. This is illustrated in Sobotta<sup>42</sup> and described by Kollmann.<sup>44</sup>

The investigations of Bradley and his associates<sup>1,2</sup> revealed that in sixty-four of their one hundred dissections the various trunks of the anterior and posterior complexes fused into common right or posterior and left or anterior trunks somewhere between the esophageal hiatus and a level 6 cm. above it. In seven of the specimens the point of fusion was at the esophageal hiatus, and in twenty-one long right or posterior and left or anterior trunks were present caudad from somewhere above the 6 cm. level. The total of these cases represented 92 per cent of their dissections. In the series of thirteen dissections by Miller and Davis<sup>3</sup> only five specimens showed single right or posterior and left or anterior trunks at or just above the esophageal hiatus. Three or more gastric nerves passed

through the hiatus anteriorly and posteriorly in the remaining eight. Statistical analysis reveals that these results are significantly at variance. The statistics derived from the dissections performed in this series likewise differ significantly from those of the former group of investigators but not from those of the latter group. The investigations of Chamberlin and Winship<sup>43</sup> showed that thirty of fifty dissected specimens had single anterior and posterior gastric nerves, the remaining twenty being of a more complex pattern. These results also are significantly different from the statistics of Bradley and his co-workers. In the series reported here only eleven of fifty specimens had single anterior gastric nerves and twenty-nine of fifty had single posterior nerves. In only seven of the fifty cases (Group 1) were single anterior and posterior gastric nerves simultaneously present.

The dissected specimens have been classified into six groups of increasing complexity on the basis of the number of trunks passing through the esophageal hiatus anteriorly and posteriorly. It was apparent, throughout, that less variation in position and number of trunks characterized the trunks on the posterior aspect of the esophagus at the hiatus. A glance at the accompanying illustrations will convince one that though the posterior gastric nerves were situated usually behind the right border of the esophagus at the level of the hiatus (forty-eight of fifty specimens), the anterior fibers were located anywhere from the right to the left border although the largest trunk was more commonly (forty of fifty specimens) in the usual left anterior location. The ease of location of this larger trunk must not blind one to the fact that there were additional anterior trunks in thirty-nine instances (78 per cent). The existence of so many additional anterior fibers made a statistical determination of the caudal limit of the anterior complex an arbitrary and rather meaningless matter since it could be determined accurately in so few instances. Again,

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dissections carried 5 cm. above and 2.5 cm. below the level of the diaphragm along one or two largest anterior trunks turned up communicating branches leading to the other smaller anterior trunks.

The foregoing study indicates that since there are eleven instances of single anterior gastric nerves and twenty-nine of single posterior nerves, the pattern of the gastric nerves about the esophageal hiatus is usually complex and that the performance of a complete vagotomy will not be accomplished in the vast majority of cases with the division of only one trunk on either aspect of the esophagus.

The transthoracic approach to the vagus nerves is usually accomplished through the bed of the seventh or eighth left rib and costal cartilage. The left pulmonary ligament is divided and the posterior mediastinal pleura opened. The trunks of the vagi are identified as they approach the sides of the esophagus from the posterior aspect of the lung roots, dissected downward and removed. The anterior and posterior gastric nerves are identified at the level of the esophageal hiatus and these trunks are dissected upward and removed. The rent in the mediastinal pleura is then sutured and the chest closed without drainage. The procedure should include stripping of the esophagus of all adventitious tissue down to the longitudinal muscle layer save the principal left-sided arterial supply.

It has been the custom in this clinic to perform vagotomy subdiaphragmatically through an upper midline abdominal incision or a curved transverse incision roughly paralleling the inferior margin of the thoracic cage. The left lobe of the liver is mobilized to the right by division of the left triangular ligament. The esophagus is freed of its attachments to the hiatus and drawn down at least 6 to 8 cm. into the peritoneal cavity. The largest anterior gastric nerve is easily identified, being usually 0.2 to 0.3 cm. in diameter. It can be followed upward and downward, its communicating branches in turn identify-

ing the other anterior gastric nerves. All adventitious tissue is removed from the anterior aspect of the esophagus down to the longitudinal muscle layer for a distance of 8 cm. over the lower esophagus and upper stomach. Pathologic examination of this tissue has revealed therein the presence of several nerve bundles which had not been determined at the operating table. The esophagus and upper stomach have then been rotated through 180 degrees to permit the performance of a similar procedure posteriorly. The constancy of location and relatively larger size of the posterior gastric nerves permit their easy identification. The same stripping is carried out equally wide posteriorly.

The majority of surgeons of the clinic believe that the subdiaphragmatic approach is preferable by reason of the opportunity presented to explore the abdominal viscera, the ease of examining the ulcer-bearing area, and the ease of performing a drainage operation if deemed advisable. As Walters and his associates<sup>2,30</sup> have already pointed out, the abdominal exploration will occasionally turn up another unsuspected pathologic finding, such as a Meckel's diverticulum.

Abdominal exploration simultaneously permits confirmation of the diagnosis and appreciation of scarring of the pylorus which may require the performance of gastric resection or gastroenterostomy. Since numerous cases of marked post-vagotomy gastric retention are being reported, some surgeons believe that gastroenterostomy should be performed simultaneously in the majority of cases.

#### SUMMARY

1. In dissections of fifty adult, thoroughly fixed cadavers, the vagus nerves passed from the posterior aspects of the lung roots to the sides of the esophagus in two to five trunks on each side.

2. These trunks descended obliquely, branching and anastomosing, the left passing to the anterior and left lateral aspect

of the esophagus and the right to the posterior and right posterolateral aspect of the esophagus.

3. There were several branches passing from the right or posterior complex downward anteriorly to join the anterior complex, and one or more branches passing posteriorly to the esophagus and downward from the anterior complex to join the posterior complex, these branches serving to render the lateral limits of the two complexes indefinite.

4. Passing through the esophageal hiatus in seven specimens there were single anterior and posterior gastric nerves; in four specimens, one anterior and two posterior nerves; in thirteen specimens, one posterior and two anterior nerves; in seven instances, two anterior and two posterior nerves; in ten specimens, three or more anterior and one posterior nerves; and in nine specimens, three or more anterior and two or more posterior nerves.

5. Subdiaphragmatically, the anterior nerve(s) split close to the hiatus into left and right terminal branches. The left branches split off to the left and were distributed to the anterior gastric wall, the fibers running perpendicularly to the axis of the stomach as do the branches of the principal nerve of the lesser curvature. The right branches consisted of one or more branches running through the lesser omentum to the liver, the principal nerve of the lesser curvature and one or more running along the lesser curvature to the incisura with branches of the left gastric artery.

6. Subdiaphragmatically, the largest branch of the posterior gastric nerve(s) terminated in the celiac ganglion, other branches following the lesser curvature and all branches being distributed to the posterior aspect of the stomach perpendicularly to its axis, the branches arising from 1 to 2 cm. below the hiatus caudad.

7. In 76 per cent of dissections nerve trunks passed caudad for variable distances between fibers of the longitudinal muscle layers of the esophagus, and in 22 per cent of specimens one or more trunks passed

through the esophageal hiatus in this fashion.

8. In all instances in which more than one trunk passed through the hiatus anteriorly, dissection along the largest anterior trunk 5 cm. above the hiatus and 2.5 cm. below revealed communicating rami to the less obvious trunks also passing through the hiatus anteriorly. More than one trunk passed through the hiatus anteriorly in 78 per cent of cases.

9. Throughout the dissections the posterior gastric nerve(s) showed less variation than the anterior nerve(s) at the hiatus, being located in 96 per cent of specimens between the posterior midline of the esophagus and the right border; and if present as two trunks, these usually were no more than 0.4 cm. apart at the level of the hiatus.

10. Anterior gastric nerve trunks could not be so dependably localized, being somewhere on the anterior aspect of the esophagus at the hiatus, although the largest trunk in 80 per cent of specimens was situated somewhere between the anterior midline and left border of the esophagus.

11. Complete vagotomy can be accomplished only by stripping the esophagus (and upper stomach in subdiaphragmatic approaches) of all obvious nerve trunks and adventitious tissue down to the outer longitudinal muscle layer over a distance of not less than 8 cm.

12. It is believed that vagotomy is technically feasible through the abdomen. This approach offers the advantages of simultaneous exploration of the abdominal viscera, examination of the ulcer-bearing area and easy performance of drainage operations or revisions of previous operations.

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# TREATMENT OF ACUTE PERITONITIS WITH AUREOMYCIN\*

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THE advent of chemotherapy as an adjunct in the management of acute peritonitis has been followed by a significant reduction in mortality. The work of Crile,<sup>1</sup> Altmeier,<sup>2</sup> Rothenberg and colleagues<sup>3</sup> and others has established the efficacy of penicillin in massive doses and the role of streptomycin and sulfadiazine in the therapy of this condition. Despite adequate surgery and efficient postoperative care it seems evident that none of the present day antibacterial agents has given a final answer, for a residual mortality still exists.

The extremely wide antibacterial spectrum possessed by aureomycin as shown by many studies<sup>4-9</sup> was an important factor prompting the use of the drug in peritonitis of all types. The mixed intestinal flora frequently found in the abdomen at the time of operation seemed logically to fit the capacities of this new antibiotic. Further, the limitations of penicillin, sulfonamides and streptomycin, alone and combined, in handling certain cases of peritonitis, coupled with the fact that our experience at Harlem Hospital has not been in line with the extremely low mortality rates recently reported in the literature, made the search for another therapeutic agent particularly desirable. This paper is a preliminary report on the use of aureomycin in the treatment of fifty-two unselected patients with acute peritonitis due to appendicitis, perforated ulcers (gastric or duodenal) and one case of perforated sigmoid diverticulum.

The group of patients was representative of that found in the average municipal

hospital, comprising that section of our population which is economically insecure, nutritionally deficient, physically impaired and deprived, in most instances, of adequate educational opportunities.

Using previously known antibiotics and a standardized postoperative regimen the over-all mortality in 406 cases of acute appendicitis at Harlem Hospital for the years 1946 and 1947 was found by Maynard<sup>10</sup> to be 4.18 per cent. There were 145 cases of acute peritonitis in this group with fifteen deaths, a mortality of 10.3 per cent. In forty cases of perforated gastroduodenal ulcers during the same period there were seven deaths with a mortality of 17 per cent. These patients received penicillin and sulfadiazine postoperatively. According to Maingot<sup>11</sup> the current mortality of perforated ulcers in the average general hospital varies from 8 to 15 per cent. Olsen and Nogore<sup>12</sup> report a 21 per cent surgical mortality in perforated ulcers for the seven years, 1938 to 1944. Luer,<sup>13</sup> covering a ten-year period, showed an 18.2 per cent mortality. Recent reports on appendicitis with peritonitis show a reduction of mortality to between 3 and 4 per cent and lower.<sup>1,2,14,15</sup>

The fifty-two cases reported in this series are analyzed in Table 1.

All but one of these patients was treated definitely by surgical intervention in an effort to remove the offending disorder and prevent further seeding of the already invaded peritoneal cavity. Drainage was instituted in 95 per cent of these cases. The surgery was performed by the resident staff under the supervision of assistant

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visiting surgeons. The age in appendical peritonitis ranged from four to sixty-eight years, and in perforated ulcers from twenty-eight to sixty-five years. For the purpose of this paper the type of peritonitis encountered was divided into two

at the time of operation by culturing the fluid found in the abdominal cavity. These findings are presented in Table II.

In addition to determining the bacteriology at operation, cultures were obtained at frequent intervals from the in-dwelling

TABLE I  
ANALYSIS OF FIFTY-TWO CASES IN WHICH AUREOMYCIN ALONE WAS USED

Disease	Total		Operative Procedure	Type of Peritonitis		Mortality, Per cent	
	No. of Cases	No. of Deaths		Localized	Generalized	Uncorrected	Corrected
Appendicitis.....	35	2	Appendectomy 32*	19	16	5.71	2.94
Perforated gastroduodenal ulcers.....	16	2	Repair perforation 16	0	16	12.5	6.67
Sigmoid diverticulum.....	1	0	Drainage 1	1	0	0.0	0.0
Totals.....	52	4	.....	20	32	7.69	4

\* One non-operative case; two drainage.

large categories, localized and spreading or generalized. In the appendicitis group there were nineteen cases of localized and sixteen cases of generalized peritonitis, with perforation found in 75 per cent of the cases. There were sixteen cases of generalized peritonitis in the ulcer group; in the case of the perforated sigmoid diverticulum the peritonitis was localized at the time of operation.

In this series of fifty-two cases there were four deaths. Two of these are included in our final mortality figures as possibly not having responded to the antibiotic although these deaths occurred early in the study at which time relatively low intramuscular dosages were used. The remaining two are excluded because postmortem findings proved them to be surgical mortalities.

In the initial phases of this study cases were alternated for control purposes, using penicillin and other antibiotics in one group and aureomycin in the second group. After approximately twenty-four cases were followed in this manner results with aureomycin were sufficiently impressive to warrant its use in all cases of peritonitis.

Bacteriologic control was established

abdominal drain until its time of removal. This procedure was followed routinely in an effort to obtain some information as to the bacterial flora present in the peritoneal cavity. At the present time we can draw no conclusions regarding this phase of the work but will discuss and analyze our findings in detail in a later paper.

As anticipated, *Escherichia coli* was the predominant organism isolated from appendical peritonitis. In all but one case it appeared in combination with one or more organisms, usually streptococci. Although anaerobes were found in some cases, the incidence was not as frequent as has been reported in some other studies.<sup>3,16,17</sup> In this type of disease a mixed flora was found far more commonly than was a pure culture although no single outstanding grouping of organisms presented itself. On the other hand, pure cultures were the rule rather than the exception in perforated ulcers. Probably because of early surgical intervention and the location of the lesion in the gastrointestinal tract, *Escherichia coli* was found in only three cases, two of which were fatal. The significance of these findings is not clearly evident at present since

TABLE II  
OPERATIVE BACTERIAL CULTURES ACCORDING TO TYPE  
OF DISEASE

Thirty-five Cases of Appendicitis with Peritonitis	No. of Cases
<i>Escherichia coli</i> plus anaerobic streptococci.....	3
<i>Escherichia coli</i> plus gamma streptococci.....	2
<i>Escherichia coli</i> plus <i>Streptococcus viridans</i> .....	1
<i>Escherichia coli</i> plus <i>Aerobacter aerogenes</i> plus gamma streptococci.....	1
<i>Escherichia coli</i> plus anaerobic streptococci plus <i>Clostridium perfringens</i> .....	1
<i>Escherichia coli</i> plus gamma streptococci plus <i>Staphylococcus albus</i> .....	1
<i>Paracolon bacilli</i> plus <i>Bacterioides funduliformis</i> .....	1
<i>Streptococcus viridans</i> plus coagulase positive beta hemolytic <i>Staphylococcus aureus</i> .....	1
Beta hemolytic streptococci.....	1
<i>Streptococcus viridans</i> .....	1
Gamma streptococci.....	1
<i>Escherichia coli</i> .....	1
<i>Staphylococcus albus</i> plus <i>Micrococcus pyogenes</i> var. <i>albus</i> .....	1
<i>Escherichia coli</i> plus anaerobic streptococci plus <i>Clostridium perfringens</i> plus <i>Bacterioides fundu-</i> <i>liformis</i> plus <i>Bacterioides melaninogenicus</i> .....	1
<i>Escherichia coli</i> plus <i>Aerobacter aerogenes</i> plus <i>paracolon bacillus</i> .....	1
<i>Escherichia coli</i> plus <i>Aerobacter aerogenes</i> plus <i>Corynebacterium pseudodiphthericum</i> plus anaerobic streptococci plus <i>Clostridium per-</i> <i>fringens</i> .....	1
<i>Escherichia coli</i> plus <i>Corynebacterium pseudo-</i> <i>diphthericum</i> plus <i>Micrococcus candidus</i> .....	1
Anaerobic streptococci plus <i>Micrococcus pyogenes</i> var. <i>albus</i> <i>Micrococcus aneareobius</i> .....	1
<i>Corynebacterium pseudodiphthericum</i> plus <i>Bac-</i> <i>terioides melaninogenicus</i> .....	1
<i>Streptococcus viridans</i> plus <i>Klebsiella pneumoniae</i> plus <i>Staphylococcus albus</i> plus <i>Clostridium</i> <i>tetanosporum</i> plus <i>Bacterioides funduliformis</i> plus <i>Micrococcus pyogenes</i> var. <i>albus</i> .....	1
Anaerobic streptococci (this patient died).....	1
Anaerobic streptococci plus <i>Bacterioides funduli-</i> <i>formis</i> (this patient died).....	1
No culture—non-operative case.....	1
Negative.....	8
Sixteen Cases of Ruptured Gastroduodenal Ulcers	
Anaerobic streptococci.....	3
Beta hemolytic streptococci.....	1
<i>Streptococcus viridans</i> .....	1
<i>Streptococcus viridans</i> plus gamma streptococci.....	1
Anaerobic streptococci plus <i>Staphylococcus albus</i> plus <i>Streptococcus viridans</i> plus <i>Clostridium</i> <i>tetanosporum</i> plus <i>Bacterioides melaninogenicus</i> plus <i>Bacillus</i> sp.....	1
Coagulase positive beta hemolytic <i>Staphylococcus</i> <i>albus</i> plus <i>Corynebacterium pseudodiphtheri-</i> <i>cum</i> .....	1
Beta hemolytic streptococci plus <i>Staphylococcus</i> <i>albus</i> plus <i>Escherichia coli</i> plus <i>Corynebacter-</i> <i>ium pseudodiphthericum</i> plus <i>Bacterioides fun-</i> <i>duliformis</i> plus anaerobic streptococci.....	1
<i>Escherichia coli</i> (these patients died).....	2
No culture taken.....	1
Negative.....	4
One Case of Perforated Diverticulum	
<i>Aerobacter aerogenes</i> .....	1

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there appears to be no clear-cut correlation between the bacteriology and the clinical course of the disease. (Table III.)

The percentage of negative cultures as shown in Tables II and III would appear to be high, particularly in peritonitis due to appendicitis. Partial explanation of these findings is related to inadequate culturing at the time of operation and the failure on the part of the house staff to follow necessary technical procedures. In the future we hope to reduce our number of negative cultures by taking swabs from the pathologic lesion in addition to those of the abdominal fluid.

The mortality in this series of fifty-two cases is presented in Table IV.

The basis of evaluation of the four deaths was the appraisal of aureomycin's failure to control or prevent the fatal termination of the peritonitis. Thus, two deaths were automatically dropped from our fatality percentage, for both were proven to be surgical deaths at postmortem examination. One death was due to a "blow-out" of the appendical stump, and in the second case two patent ulcers were found on the posterior wall of the first part of the duodenum and were feeding the peritoneal cavity from a retroperitoneal abscess. Of the other two deaths, one occurred in a forty-five year old colored male with a perforated appendix who died suddenly three and one-half days postoperatively from a pulmonary embolus. The diagnosis was made by x-ray and clinical findings; no postmortem was obtained. The second death was in a sixty-five year old white female, acutely ill, with a perforated gastric ulcer, estimated at about eighty-six hours' duration prior to operation. The patient lived for forty hours after operative intervention during which period aureomycin was administered. The inclusion of two deaths in the series to date gives an over-all mortality of 4 per cent; a 2.94 per cent mortality in appendical peritonitis; and a 6.67 per cent mortality in perforated ulcer cases. While our series is too small as yet to draw any definite conclusions regarding the efficacy of aureomycin, comparison

TABLE III  
CORRELATIONS BETWEEN CLINICAL COURSE OF DISEASE AND BACTERIOLOGY

Case No.	Age	Disease	Organism	Hospital Days	Course	Complication
1	37	Perforated gastric ulcer	Beta hemolytic streptococci	13	Uneventful	None
2	34	Appendical abscess	Non-operative case	23	Uneventful	None
3	28	Gastric ulcer	Negative	18	Uneventful	None
4	34	Appendicitis	Negative	9	Uneventful	None
5	43	Gastric ulcer	Anaerobic streptococci	36	Stormy	Chest, extremities, intra-abdominal abscess, wound infection
6	5	Appendicitis	Paracolon bacilli plus Bacteroides funduliformis	13	Uneventful	None
7	38	Gastric ulcer	No operative culture	20	Moderate	Chest, wound infection
8	9	Appendicitis	Micrococcus anaerobius	12	Uneventful	None
9	33	Appendicitis	Negative	9	Uneventful	None
10	46	Appendicitis	Escherichia coli plus gamma streptococci plus Staphylococcus albus	20	Stormy	Chest, abdomen, genitourinary, wound abscess
11	48	Gastric ulcer	Negative	22	Uneventful	None
12	5	Appendicitis	Escherichia coli plus anaerobic streptococci plus Clostridium perfringens	24	Stormy	Wound abscess
13	32	Duodenal ulcer	Gamma streptococci plus Streptococcus viridans	20	Stormy	Chest, wound abscess
14	46	Gastric ulcer	Negative	24	Uneventful	None
15	43	Appendicitis	Negative	10	Mild	Chest
16	38	Appendicitis	Beta hemolytic streptococci	12	Uneventful	None
17	34	Appendicitis	Negative	19	Moderate	Chest
18	55	Sigmoid diverticulum	Aerobacter aerogenes	14	Uneventful	None
19	34	Duodenal ulcer	Anaerobic streptococci	37	Uneventful	None
20	21	Appendicitis	Streptococcus viridans plus coagulase positive hemolytic Staphylococcus aureus	9	Uneventful	None
21	24	Appendicitis	Streptococcus viridans	25	Stormy	Chest, pelvic abscess
22	59	Appendicitis	Escherichia coli plus Aerobacter aerogenes plus gamma streptococci	22	Moderate	Chest, wound abscess
23	7	Appendicitis	Escherichia coli plus gamma streptococci	13	Uneventful	None
24	47	Appendicitis	Negative	9	Uneventful	None
25	11	Appendicitis	Escherichia coli plus anaerobic streptococci	20	Mild	None
26	28	Duodenal ulcer	Streptococcus viridans	19	Moderate	Chest, wound infection
27	43	Gastric ulcer	Negative	16	Uneventful	None
28	4	Appendicitis	Escherichia coli	14	Uneventful; developed abscess at home	None
29	24	Appendicitis	Negative	11	Uneventful	None
30	25	Appendicitis	Negative	12	Uneventful	None
31	28	Appendical abscess	Escherichia coli plus gamma streptococci	17	Mild	Diarrhea, three days
32	39	Appendicitis	Escherichia coli	18	Stormy	Fascial slough, thrombophlebitis
33	33	Gastric ulcer	Anaerobic streptococci	30	Stormy	Evisceration, delirium tremens, chest
34	15	Appendicitis	Negative	9	Uneventful	None
35	66	Appendicitis	Escherichia coli plus anaerobic streptococci	25	Uneventful	None
36	17	Appendicitis	Escherichia coli plus anaerobic streptococci	9	Uneventful	None

TABLE III (Continued)

Case No.	Age	Disease	Organism	Hospital Days	Course	Complication
37	30	Appendicitis	Staphylococcus albus plus Micrococcus pyogenes var. albus	9	Uneventful	None
38	49	Appendicitis	Gamma streptococci	11	Moderate	Pelvic abscess
39	69	Appendicitis	Escherichia coli plus anaerobic streptococci plus Clostridium perfringens plus Bacteroides funduliformis plus Bacteroides melaninogenicus	22	Mild	Wound abscess
40	35	Appendicitis	Anaerobic streptococci plus Micrococcus pyogenes var. albus	20	Moderate	Wound abscess
41	21	Appendicitis	Escherichia coli plus Micrococcus candidus plus Corynebacterium pseudodiphthericum	13	Mild	Ileus
42	9	Appendicitis	Bacteroides melaninogenicus plus Corynebacterium pseudodiphthericum	15	Uneventful	None
43	42	Appendicitis	Streptococcus viridans plus Klebsiella pneumoniae plus Clostridium tetanosporum plus Bacteroides funduliformis plus Staphylococcus albus plus Micrococcus pyogenes var. albus	13	Moderate	Ileus
44	24	Duodenal ulcer	Coagulase positive beta hemolytic Staphylococcus albus plus Corynebacterium pseudodiphthericum	14	Uneventful	None
45	24	Duodenal ulcer	Streptococcus viridans plus Staphylococcus albus plus Bacteroides melaninogenicus plus Clostridium tetanosporum plus Bacillus sp. plus anaerobic streptococci	16	Uneventful	None
46	47	Appendicitis	Escherichia coli plus Aerobacter aerogenes plus paracolon bacilli	10	Mild	Wound infection
47	33	Duodenal ulcer	Beta hemolytic streptococci plus Staphylococcus albus plus Escherichia coli plus Corynebacterium pseudodiphthericum plus Bacteroides funduliformis plus anaerobic streptococci	19	Uneventful	None
48	42	Appendicitis	Escherichia coli plus Aerobacter aerogenes plus Corynebacterium pseudodiphthericum plus anaerobic streptococci plus Clostridium perfringens	14	Mild	Postoperative pneumonia
49	65	Duodenal ulcer	Escherichia coli	40 hours	Patient died of peritonitis	
50	28	Duodenal ulcer	Escherichia coli	10	Patient died of peritonitis	
51	45	Appendicitis	Anaerobic streptococci plus Bacteroides funduliformis	4	Patient died of pulmonary embolus	
52	42	Appendicitis	Anaerobic streptococci	10	Patient died of peritonitis	

with previous mortality figures at this hospital is very encouraging and further studies with the drug are indicated.

Aureomycin\* can be administered by either the intramuscular, intravenous or oral route, apparently being clinically

ately postoperatively the patient is given a 500 mg. intravenous dose and this is repeated every twelve hours thereafter for generally forty-eight hours. On the third postoperative day the Wangenstein suction is clamped off and two 250 mg.

TABLE IV  
MORTALITY

Patient	Hospital Number	Onset to Operation (hr.)	Diagnosis	Time Lived	Cause of Death
A.O.	12196	26	Perforated ulcer	10 hr.	Uncontrolled peritonitis; no autopsy
L.M.	16581	72	Gangrenous appendicitis with generalized peritonitis	3½ days	Pulmonary infarction (by x-ray and clinical); no autopsy
W. H.	12072	26	Perforated ulcer	10 days	Patent duodenal ulcers 2, peritonitis; postmortem
J. F.	17059	40	Gangrenous appendicitis with peritonitis	10 days	Appendical stump "blow out"; massive intra-abdominal and retroperitoneal abscess; post-mortem

effective regardless of the method used. Initially, only intramuscular aureomycin was available and the search for an optimum dosage level began with this form of the drug. It was quickly apparent that our original dosages were too low, for despite clinical improvement morbidity was often prolonged. Clinical response to the drug was used as the basis for increasing the dosage rather than correlating the mg. dosage to Kg. of body weight. As soon as sufficient amounts of the antibiotic became available, the other two methods were used by choice. Since the combined intravenous and oral regimen we have had no fatalities.

In the first patients treated by the intravenous route, our daily dosage ranged up to 2 Gm. in an effort to find the minimal dose giving optimum clinical response. When it was determined that clinical results were very good with 1 Gm. of drug daily, we established the standardized routine described below which has been followed in all of our later cases. Immedi-

capsules are given orally every twelve hours for an average period of seven to ten days depending upon clinical indications. In children, the same general scheme has been followed but dosage has been cut approximately in half. For intravenous use the dry powder is dissolved in a 500 cc. flask of 5 per cent glucose in distilled water and introduced within an hour. This is given as part of the usual postoperative intravenous administration of fluids. In out hands this has proven to be a simple and efficient means for administering the drug.

To date there have been no toxic responses to the drug severe enough to cause cessation of therapy, regardless of the route of administration. When the intramuscular route is used, the only reaction has been some slight pain on injection. When given intravenously, a chemical phlebitis has developed in ten out of twenty-two cases, and it has ranged from mild to moderately severe. This complication did not alter the usual course of the disease nor prolong morbidity. With oral administration it is particularly interesting to note that we have not seen the nausea and vomiting or

\* The aureomycin was supplied through the courtesy of the Lederle Laboratories, Division of the American Cyanamid Company, Pearl River, New York.

the type of diarrhea seen occasionally in other patients that have been treated in this hospital for ulcerative colitis (fifteen cases), various wound infections (sixty cases), compound fractures (ten cases) and genitourinary infections (twelve cases). In two cases there was mild nausea and some vomiting, but an interpretation of this was difficult because of the peritonitis present. Laboratory studies have shown no changes in blood chemistry, and urine studies have shown no evidence of kidney damage.

Blood levels have been determined in several cases and demonstrable levels have been found at all times with both the oral and intravenous route. At present, no conclusions have been reached as to the optimum therapeutic blood level.

#### SUMMARY

1. This is a preliminary report of the use of aureomycin in the treatment of fifty-two unselected patients with acute peritonitis due to appendicitis, perforated gastroduodenal ulcers and one perforated diverticulum.

2. There has been a definite reduction of mortality in this small series when compared with our hospital mortality for the previous two years. All deaths occurred prior to the introduction of the intravenous-oral therapeutic regimen.

3. The bacteriologic findings were inconclusive when correlated with clinical course. A mixed flora was the common finding in appendical peritonitis while a pure culture was the usual finding in perforated ulcers.

4. The combination of initial intravenous dosage followed, as soon as feasible, by oral administration of the drug has proven clinically to be the most successful procedure. Five hundred mg. of the drug with 500 cc. of 5 per cent glucose in water as the vehicle was given by infusion twice daily. As soon as Wangensteen suction could be safely interrupted, oral dosage of 500 mg. twice daily was begun and usually continued for an average of seven to ten days.

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5. Minimal toxic reactions were noted. The drug produced a chemical phlebitis in some patients but did not prolong the course of the disease.

6. Aureomycin has proven to be of significant value in the therapy of peritonitis. Our series is too small to define the precise role of the antibiotic in this grave infection but results are impressive enough to warrant further extensive clinical investigation of the drug.

7. This work is still in progress and a detailed report will be published at a later date.

Thanks are due to Dr. Solomon Weintraub, Director of Pathology, for his helpful cooperation; to Mr. A. C. Dornbush and Mr. E. J. Pelcak for conducting the studies on blood levels; to Dr. Paul A. Eichorn for much information and helpful suggestions; to Dr. Frank R. deLuca for his assistance; and to Miss Mary McKenna for valuable help.

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SMITH and Jordon studied 600 cases of gastric ulceration and found malignancy in about 10 per cent. This incidence is not great enough to permit one to generalize and affirm that all patients with gastric ulcers should be subjected to a subtotal gastrectomy. Gastric malignancy seems to occur much more frequently in men but, unfortunately, the clinical symptoms between benign and malignant gastric ulceration are too similar to permit a careful evaluation and differentiation. A greater percentage of gastric ulcers of the fundus and/or of the greater curvature becomes malignant than in other parts of the stomach. A benign duodenal ulcer can coexist with a malignant gastric ulcer, hence, the coexistence of these two types of ulceration cannot be used as an argument in favor of the gastric lesion being benign. However, if a gastric ulcer does not respond to a proper medical regimen after a period of two months or if it recurs, surgical resection of a major part of the stomach is usually justified even though often only a benign gastric lesion will be found. (*Richard A. Leonardo, M.D.*)

# INJECTION INTO THE INTERCOSTAL NERVES FOR THE RELIEF OF POSTOPERATIVE PAIN\*

FREDERICK M. GRAHAM, M.D., THOMAS H. SELDON, M.D. AND JAMES T. PRIESTLEY, M.D.

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FOR a long time many surgeons have sought an entirely satisfactory analgesic agent which would relieve postoperative pain. A convalescent period free from pain would be not only a great boon from a humanistic viewpoint but would add materially to the smoothness and rapidity of convalescence. For example, surgeons have been particularly cognizant of an inhibited respiratory function after operation on the upper portion of the abdomen. Patey, Churchill and McNeil, Zollinger and Powers have independently demonstrated a decrease in vital capacity after surgical procedures on the abdomen. Narcotics have been invaluable agents in combatting postoperative pain and discomfort. Unfortunately, they have undesirable side effects which are chiefly depressant in nature. The processes of respiration, bowel activity and micturition, already burdened by a surgical procedure, may be further embarrassed by heavy sedation. Obviously, a postoperative period free of pain would have many advantages.

In recent years attention has been directed to regional anesthesia as a possible means of preventing postoperative pain. Crile in 1918 employed local wound infiltration with quinine and urea in conjunction with his anoci-association theory of anesthesia. Capelle in 1935, however, was the first to employ this principle with the idea of allaying postoperative pain and thereby increasing pulmonary ventilation. By means of retention needles he infused the incised area continuously with a solution of procaine hydrochloride. Gius later reported improvement in two cases of postoperative atelectasis after paravertebral block with procaine hydrochloride.

Zollinger apparently was the first to study the effect of intercostal nerve block in regard to convalescence after operation. After the intercostal nerves were blocked by the injection of a solution of eucupine and procaine hydrochloride in oil, he found a definite increase in vital capacity during the immediate postoperative period. Starr and Gilman have reported similar results. Belinkoff<sup>2-4</sup> studied a series of 100 patients who underwent abdominal operation, in which he produced intercostal block with a solution of monocaine and benzyl alcohol in oil. More than 80 per cent of the patients had a smooth convalescence as a result. According to McCleery, Zollinger and Lenahan in a series of cases which they reported recently, intercostal block was produced successfully, postoperatively, with nupercaine in oil in approximately half of the patients who received the injections. In those cases in which the block was effective, the authors found an increase in vital capacity after operation and a decrease in pulmonary complications and narcotic requirements. However, the controls used in some of these studies just referred to might seem open to question.

## INJECTION

*Method.* The method used to inject the anesthetic solution into the intercostal nerves was essentially the same as that described by Bartlett, Zollinger and Belinkoff<sup>2</sup>. Two and one-half to 3 cc. of the anesthetic agent was injected into each of the intercostal nerves from the sixth to the eleventh, inclusive. When the incision was some distance from the midline, only the ipsilateral nerves were blocked. If a transverse, midline or near-midline incision was

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necessary, bilateral intercostal block was induced. All injections were administered immediately on completion of the operation. Hollinshead and McCleery and his co-workers have stated that the antero-posterior site of the injections may be

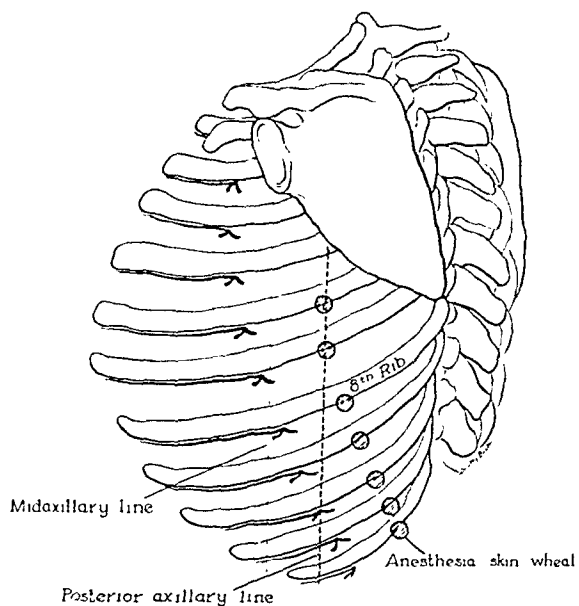


FIG. 1. Points at which anesthetic skin wheals are made. Through these wheals needles are inserted into the regions of the intercostal nerves.

important. Infiltration of the intercostal nerve proximal to its division into lateral cutaneous and anterior branches probably offers greatest assurance of a complete block. This can be accomplished by injection of the anesthetic solution into the sixth intercostal nerve in the posterior axillary line and by injection of the solution into the succeeding intercostal nerves, in a line that extends gradually, posterolaterally from that point. Figure 1 illustrates the sites of infiltration which were employed in this study. Some investigators have feared that regional block in this area would involve the motor innervation of the abdominal musculature and that weakness would result. As will be discussed later, the anesthetic agent employed in this work has no effect on motor components of nerves.

*Anesthetic Agent Employed.* The choice of a suitable anesthetic agent presented a problem. One was desired which would be

effective for a minimum of four days after operation. Initially, a cocaine derivative in oil was used and intercostal block was produced in ten patients. It did not seem to be effective, however, for a sufficient period. A commercial solution of ammonium sulfate known as "dolamin"\* was then considered. Dolamin is composed of benzyl alcohol 0.75 per cent, ammonium sulfate 0.75 per cent, and sodium chloride 0.48 per cent in sterile water. Judovich and Bates have demonstrated experimentally that the ammonium ion obliterates C fiber potentials when injected into a nerve trunk. This selective action relieves pain although it has no effect on skin sensation or on motor components of the nerve trunks.

Experimental and clinical observations have shown that the ammonium ion relieves pain effectively for a matter of hours to three or four days or longer. In our experience the effect of this drug usually persists for at least several days. Lundy has had considerable clinical experience with this agent in the treatment of various neurologic, intractable and postoperative pain. He has found it effective in well over 50 per cent of the cases and in a higher percentage than this when the needles used for the injection were placed accurately with the help of roentgenograms. McCarty has injected dolamin into the intercostal nerves under direct vision when he has performed thoracolumbar sympathectomy. He believes that patients so treated suffer much less pain during convalescence. Flashman and Lundy employed dolamin to induce paravertebral block in a case of crushing injury of the thorax. There was immediate diminution of pain and increase in pulmonary ventilation. Dolamin has satisfied most of the requirements of an ideal anesthetic agent for infiltration of the intercostal nerves. It is non-toxic, effective over a prolonged period and has a selective action on pain-conducting mechanism. Dolamin was therefore employed throughout our study.

\*Dolamin is prepared by Harvey Laboratories, Philadelphia, Pennsylvania.

## METHOD OF STUDY

*Series 1. Procedure:* Fifty patients who required operation on the upper portion of the abdomen were studied. Dolamin was used in some cases to produce intercostal block while the control group received only

TABLE I  
OPERATIVE PROCEDURES PERFORMED IN SERIES I

Procedures	No. of Patients
Gastric resection.....	18
Cholecystectomy.....	14
Vagotomy and gastro-enterostomy.....	3
Cholecystectomy and choledochostomy.....	3
Other procedures.....	12
Total.....	50

intercostal injections of sterile isotonic solution of sodium chloride. Only the anesthetists knew the type of solution used in each case and selection of the patients followed no set pattern. During the post-operative period an attempt was made by the house and staff doctors in attendance to determine in each case whether dolamin or isotonic solution of sodium chloride had been injected. It was thought that this method would afford more reliable information than if the doctor who attempted to evaluate the effectiveness of the injection knew what solution had been used.

Evaluation of the injections was carried out on a basis of subjective pain, narcotic requirements, physiologic functions (respiration and micturition in particular) and postoperative complications. It was soon apparent that the results were not dramatic. Clinical criteria do not exist by which patients' pain and discomfort can be definitely evaluated on a comparative basis. Thresholds of pain are so unpredictable that subjective expression is almost valueless from a statistic standpoint. It was rarely possible to state unequivocally that a given patient had had an injection of dolamin to produce intercostal block and that another patient had received only isotonic solution of sodium chloride. Table I lists the type of operative procedures performed on the patients in series 1.

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*Results:* On the basis of clinical observations it was thought that twenty-eight patients had received dolamin and twenty-two patients had received isotonic solution of sodium chloride. This interpretation was checked with the records of the Section on

TABLE II  
CLINICAL ANALYSIS OF INFILTRATION OF INTERCOSTAL NERVES WITH DOLAMIN OR ISOTONIC SOLUTION OF SODIUM CHLORIDE

Solution	Pa-tients	Clinical Interpretation		Correct Interpretations, Per cent
		In-jected	Not In-jected	
Dolamin.....	30	19	11	63
Isotonic solution of sodium chloride.....	20	12	8	60

Anesthesiology. The number of cases in which dolamin was injected and the number of cases in which isotonic solution of sodium chloride was injected are shown in Table II. Correct interpretations were made in 63 per cent of the cases in which dolamin was injected and in 60 per cent of the cases in which isotonic solution of sodium chloride was injected. Theoretically, if a difference had not been noted in these two groups of patients, the results in 50 per cent of the cases in each group would have been interpreted correctly. The results therefore indicate some beneficial effect from the injection of dolamin as compared with isotonic solution of sodium chloride although the difference is not striking.

The average requirement for narcotics was somewhat lower among the patients who received dolamin than among the control series. (Table III.) An average of 4.5 hypodermic injections of a narcotic was required for each patient in the former group and an average of 5.2 injections for each patient in the latter group. This shows a slight but perhaps insignificant difference. The incidence of urinary dysfunction and other complications was approximately the

same for both groups. (Table III.) As shown in Table IV the incidence of pulmonary complications was relatively high (four cases of atelectasis or 13 per cent) among those who received injections of dolamin; there were no instances among the control

TABLE III  
COMPARATIVE EFFECT OF INTERCOSTAL INJECTION WITH DOLAMIN OR STERILE ISOTONIC SOLUTION OF SODIUM CHLORIDE ON POSTOPERATIVE NARCOTIC REQUIREMENTS, URINARY FUNCTION AND COMPLICATIONS

Solution	No. of Cases	Narcotics, Average Number Hypodermic Injections*	Catheterizations		Complications	
			No.	Per cent	No.	Per cent
Dolamin....	30	4.5	15	50	8	26.6
Isotonic solution of sodium chloride..	20	5.2	11	55	5	25.0

\* The figures represent the average number of hypodermic injections for each patient given during the postoperative period. Any administration of morphine or equally potent narcotic was considered a unit.

series. This would appear to be coincidental and not statistically important. Some investigators have reported occasional instances of pneumothorax or pleural effusion which resulted from intercostal block. These complications were not encountered in this series.

*Series 2. Procedure:* Study of the results in the fifty cases in series 1 showed that dolamin was somewhat favored for intercostal nerve block for the relief of postoperative pain; the results, however, were not unequivocal. From a purely objective standpoint, the most tangible criterion of pain was the narcotic requirement. There was some question as to whether or not this factor had been controlled carefully enough. Nurses may administer a hypodermic injection for "restlessness" at bedtime although the patient may be having little or no pain. To obviate this situation,

if possible, it was decided to study a series of patients to whom narcotics were given postoperatively only on the specific order of a house doctor, and only when the patients definitely complained of pain. In series 2, 100 consecutive patients who had had

TABLE IV  
POSTOPERATIVE COMPLICATIONS ENCOUNTERED IN SERIES I

Complication	Patients	
	Injected with Dolamin	Injected with Isotonic Solution of Sodium Chloride
Thrombophlebitis, suspected or proved.....	0	3
Atelectasis, presumptive and proved.....	4	0
Ileus, severe abdominal distention, or both.....	1	2
Wound infection (mild).....	1	0
Urinary infection (mild).....	1	0
Peritonitis (death resulted on sixteenth day; operation, total gastrectomy for carcinoma)...	1	0
Total.....	8	5

major operations on the upper portion of the abdomen, were studied with this plan in effect. Fifty patients received dolamin for intercostal block and fifty patients received no intercostal injection whatever. In the cases in which injections were given the method used was identical to that employed in the first series of cases. Comparative results in the experimental and control groups were based on narcotic requirements, urinary dysfunction and other complications. (Table V.)

*Results:* Patients in series 2 who received dolamin to produce intercostal nerve block required an average of 4 doses of a narcotic during the postoperative period. Patients in whom intercostal block was not produced required an average of 4.6 doses. (Table VI.) The incidence of urinary dysfunction and other complications was the

same for the two groups. In each group there were two instances (an incidence of 4 per cent) of pulmonary complications, each of which was a case of atelectasis. (Table VII.) There were three deaths in series 2 (Table VII); none of them was

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TABLE V  
OPERATIVE PROCEDURES IN SERIES 2

Procedure	No. of Patients
Gastric resection.....	37
Cholecystectomy.....	16
Cholecystectomy and choledochostomy.....	9
Exploration for inoperable carcinoma.....	9
Abdominal vagotomy and gastro-enterostomy	4
Exploratory laparotomy.....	4
Transthoracic vagotomy.....	3
Choledocholithotomy.....	3
Other surgical procedures.....	15
Total.....	100

TABLE VI  
EFFECT OF POSTOPERATIVE INJECTION WITH DOLAMIN  
ON NARCOTIC REQUIREMENT, URINARY FUNCTION  
AND COMPLICATION—SERIES 2

	No. of Patients	Hypodermic Injections, Average Number	Catheterizations		Complications	
			Pa-tients	Per cent	Pa-tients	Per cent
Dolamin injected..	50	4.0	15	30	10	20
No intercostal injection.....	50	4.6	15	30	11	22

related in any way to the intercostal injections.

An effort to control carefully the administration of narcotics after operation did not affect the results materially. In both series studied there is minimal though definite evidence that injection of the intercostal nerves with dolamin does diminish postoperative pain. Evidence is not present, however, that such injections have any influence on the incidence of postoperative complications. The factor of early ambulation may have some bearing on this finding. Without exception all patients in both series were ambulatory either the evening of the day of operation or the day after. Undoubtedly, ambulation tends to augment all physiologic functions, particularly those of respiration, mictur-

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TABLE VII  
POSTOPERATIVE COMPLICATIONS—SERIES 2

Complications	Intercostal Nerve Block, Dolamin	No Block
Atelectasis.....	2	2
Thrombophlebitis, suspected or proved.....	2	3
Severe abdominal distention.....	3	0
Mild infection or slight separation of wound.....	0	3
Urinary infection.....	1	1
Pulmonary embolism (ligation of femoral vein).....	1	0
Peritonitis (death on ninth day after gastrectomy for carcinoma).	0	1
Gastric hemorrhage (death on twelfth day after operation for inoperable carcinoma of stomach).	1	0
Hepatic coma (death on tenth day after operation for inoperable carcinoma of biliary system)....	0	1
Total.....	10	11

operative pain by means of intercostal nerve block.

#### COMMENT

We have found on further experience with dolamin that this drug is an effective anesthetic agent when it is used to infiltrate sensory nerves and that its action usually persists for from a few hours to three or four days. On the basis of the current study it is obvious that intercostal injection of dolamin at the conclusion of various operative procedures on the upper part of the abdomen does not uniformly allay postoperative pain to a significant degree in a large majority of cases. On the other hand, a few patients experienced only minimal pain in the region of the incision after injection of dolamin. It is also true that approximately 60 per cent of

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patients who had received an intercostal injection of dolamin postoperatively experienced a sufficient analgesic effect from this treatment to be recognized clinically when compared with a control group of patients who had received an injection of isotonic solution of sodium chloride. From this study one concludes that although an analgesic drug such as dolamin, injected intercostally, may afford partial relief to some patients, it leaves considerable to be desired from the viewpoint of the ideal remedy for relief of all postoperative pain. This statement is, of course, based on the assumption that the substance used was injected accurately into the intercostal nerves or into the tissues in the immediate vicinity of the nerves and that it is an effective analgesic agent. In an attempt to interpret the results of this study one must, of course, consider the possibility that a major portion of pain which is experienced postoperatively is not mediated through the skeletal nerves. These results seemed worthy of mention as they are somewhat at variance with other articles on the subject.

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# SKELETAL PINNING AND EXTERNAL FIXATION

## PROS AND CONS

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TREATMENT of fractures is a constant challenge to the surgeon because no two fractures are identical. A fracture of a long bone at a certain level usually produces a more or less characteristic deformity. If the fracture is transverse, oblique or comminuted, there may well be a variation of the deformity. Fractures near or into joints also come into this category. It is these unusual variations that pose perplexing problems.

No one method of treatment can be used to advantage in all fracture cases or in all cases that are somewhat similar. Closed reduction and application of a cast is effective and applicable in the majority of cases. Open reduction can be used in many other cases but is merely a form of internal fixation and often additional external fixation is also necessary. Still other patients are best treated by traction although this necessitates a long period of bed rest undesirable in any case but particularly risky for elderly individuals.

In 1942, having encountered a number of particularly difficult fractures that could not be as satisfactorily treated by any of the more common methods, the author investigated skeletal pinning and external fixation. It is an old, old method of treatment revived in recent years. Several types of apparatus are available bearing the developers' names, Roger Anderson, Stader and Haynes to mention a few. All have the same underlying principle, namely, multiple pins inserted into the bone at different angles and then fixed by means of external bars connected to the pins by clamps. Some use free pins while others have pins in a bar that necessitate the use of fixed angles of insertion. The apparatus which has free

pins is more universally adaptable to unusual situations.

Recently the treatment of fractures by means of pins and bars was termed the "ambulatory treatment." Many of the profession are under the impression that this means weight-bearing is obtainable. This is not true. The expression was coined to illustrate how patients with fractures ordinarily treated with traction and bed rest can now be up and about on crutches.

The advocates of skeletal pinning and external fixation attribute to it certain virtues. The multiple pins inserted at a "V" angle seemed to give perfect control of both fragments in any direction. The use of a reduction frame permitted anatomic approximation with a minimum of manipulation. Fixation of the pins with easily applied external rods maintained the reduction. The equipment was light in weight and caused the patient little discomfort. Furthermore, the joints above and below the fracture were free to move, thus preventing stiffness of the joints.

After purchasing our apparatus, we made an intensive study of proper application. While the equipment looks simple and its application easy, it soon became apparent that there was much to learn. First there are particular sites at which the pins should be inserted, not only for anatomic reasons but to obtain the best mechanical advantage. Before inserting the pins it is preferable to obtain approximate reduction for the soft tissues must be considered. The pins should be located where there is a minimum of motion. Use of the proper size pins to stand the strain is important. A light pin bends and causes pressure necrosis in the bone or soft tissues. It is also advisable



to insert the pins with a hand chuck to avoid heat necrosis of the bone. When necrosis occurs, the pins loosen. All of this is mentioned to emphasize one very important point, namely, in all surgical procedures, one must be very familiar with the method in order to use it correctly.

One technic or several technics for the use of skeletal pinning and external fixation have been worked out for the treatment of practically every type of fracture. The author has used many but not all of the procedures. As he gained experience with the method he began to limit its use to certain selected cases, those in which simpler methods were not as suitable. The reasons are as follows: (1) Insertion of pins is usually slower than closed reduction and casting. Local anesthesia can be used but general anesthesia is usually indicated. Minimizing this is considered important. (2) Anatomic reduction with reduction apparatus is not quite as simple as it appears to be. Functional approximation is often obtained easier by other forms of treatment. (3) Drainage from around the pins is annoying. It is produced by pressure necrosis of the soft tissue and is only occasionally purulent in nature. (4) Occasionally pins loosen due to pressure or heat necrosis of bone. When this occurs, the treatment has to be modified. Additional pins must be added or all pins removed and immobilization obtained by a cast or traction. (5) Joint motion often is not as great as might be expected. This is because the pins traverse movable soft tissue with resultant pain. Movement is thus protectively minimized.

Complications of one kind or another develop in a certain percentage of all surgical cases. Fracture cases are no exception. It is our constant desire to alleviate these complications that drives us to perfect our technics and develop newer and better methods.

Osteomyelitis is one of the complications that has always been the greatest argument against the use of pins or wires. It is believed that motion of the pin from side

to side permits access of infection. The use of multiple pins inserted at an angle through both cortices gives the greatest bearing surface or holding surface possible in the bone and limits motion of the pins. Whenever motion develops either with multiple pins or a single pin, it is due to loosening from necrosis caused by pressure or heat. It can occur and does occur even with multiple pins, and when motion does develop the probability of infection is greater. If osteomyelitis occurs after pinning, a ring sequestrum is almost always present. These are difficult to demonstrate by x-ray unless the pin hole is viewed on end. Curettement of the pin hole usually provides a cure if done early.

If there is soft tissue movement about the pins, local infection is likely to develop. This may be a small affair but large abscesses in the fascial spaces have developed in our experience. They present a real problem that must be treated radically. Only in a few instances has it been necessary to remove the pins because of the infection. Extension of the infection into the bone has never occurred unless there was already concurrent loosening of the pin.

In spite of the above shortcomings and possible complications the author believes that the use of skeletal pinning and external fixation is of special value in certain cases in the following groups:

#### CASE REPORTS

**CASE 1. *Fracture dislocations:*** A twenty-eight year old soldier suffered multiple injuries in an automobile accident in August, 1943. He had a severe head injury and was in coma. There was an obvious fracture of the left femur with displacement of the proximal fragment typical of an anterior dislocation of the hip. The femur was placed in skin traction and all efforts directed toward treating the head injury and associated shock. It was thirteen days before his condition permitted definitive treatment of the fracture dislocation. Then under spinal anesthesia pins were placed in the proximal and distal fragments, the fracture reduced and external fixation applied. With an intact extremity, the dislocation was relatively



FIG. 1. Fracture of shaft of femur with anterior dislocation of hip; closed reduction of dislocation made possible by initial fixation of fractured fragments.



FIG. 2. Case 1. Illustrating the arrangement of pins and bars and ease with which the patient can ambulate.

easily reduced with traction and manipulation. Some displacement of the fracture fragments occurred. They were realigned and solid healing of the fracture occurred in five months. Minimal residual limitation of flexion of the knee resulted. Follow-up films fifteen months after injury showed the head of the femur viable. (Figs. 1 and 2.)

**CASE II. Fractures into joints:** These can usually be treated only by traction through the joint. Occasionally open reduction and internal fixation with screws is possible. Skeletal pinning, however, is universally adaptable. Pins are placed in the major fragment and in the intact bone above or below the joint. The fracture fragments are reduced by manipulation using traction to take full advantage of the natural muscle and ligamentous pulls. These frequently produce reduction without direct molding. When reduction has been obtained, position is maintained by fixation with external rods. A thirty-eight year old soldier suffered a comminuted supracondylar fracture through the right humerus in a fall in July, 1943. This

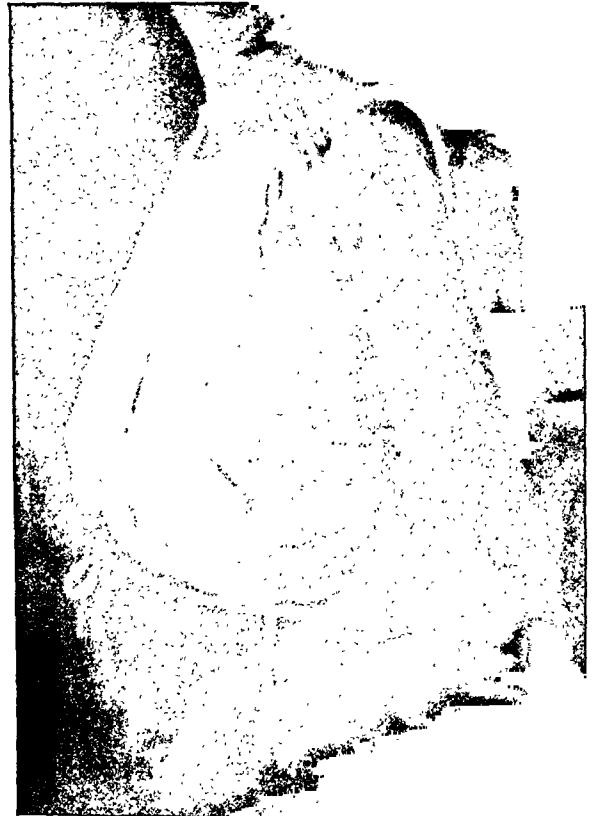


FIG. 3. Case II. Epicondylar fracture of humerus into elbow joint fixed with skeletal pins and bars.

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FIGS. 4 TO 6. Case III. Figure 4 shows fracture of upper third of femur, treated by plating with non-union; Figure 5 shows the patient ambulatory on crutches after removal of plate and correction of angulation; the end result six months later is shown in Figure 6.

area was already deformed due to mal-union of an old fracture suffered in childhood. Marked hemorrhage into the soft tissues produced ischemia when the elbow was flexed to maintain reduction. Therefore, skeletal pins were inserted and fixed as seen in the accompanying illustration. The patient was quite comfortable. Good union was obtained and elbow motion was within 5 degrees of what it had been before refracture. (Fig. 3.)

**CASE III. Fractures of the femoral shaft:** This type of fracture is ordinarily treated by traction for a period of months or by open reduction and cast. Both methods limit the patient's activity a great deal. By using skeletal pins and external fixation reduction can be maintained and the patient's activity limited very little. Active patients can ambulate on crutches with ease while more feeble ones can be easily handled by attendants. A sixty-four year old doctor incurred a high shaft fracture of the femur which was treated by open reduction, plating and casting. Angulation at the fracture site occurred. He came to us ten months after injury

with angulation and non-union. The plate and screws were removed, the bone ends freshened and realigned and position maintained by skeletal pins and external fixation. Good union was obtained. This patient was in a position to evaluate the spica cast and skeletal pinning treatments. He much preferred the latter. (Figs. 4 to 6.)

**CASE IV. Lower extremity fractures in handicapped patients, those with amputations or deformities of legs or arms that prevent use of crutches:** The lighter weight of the equipment permits the patient to handle himself better. (Fig. 7.)

**CASE V. Maintenance of position after arthrodesis:** The equipment is much less cumbersome than a spica after fusion of a knee yet will maintain position perfectly. Should some absorption of the bone at the point of fusion occur it is a simple matter to loosen the external bars, impact the bones and then reapply the external fixation. A tuberculous knee joint in a twenty-nine year old negro was fused. There was some strain on the pins as they were in-



FIG. 7. Case iv. Both bone fractures of lower leg in an amputee; the tibial caliper brace was applied for added protection.



FIGS. 8 and 9. Case v. Figure 8 shows bone and soft tissue loss following extensive injury to upper arm; Figure 9 illustrates the utilization of pins to maintain position during and after bone grafting procedure.



FIGS 10 and 11. Case v. Note growth of graft at end of five years shown in Figure 10. Fixation apparatus was applied because of recent fracture through graft. Figure 11 shows the present condition of arm; note marked soft tissue loss and scarring; functional result was remarkably good.



FIGS. 12 TO 14. Case VI. Compound fracture of both bones of lower leg fixed with pins and external bars shown in Figure 12; Figure 13 shows sequestration occurring at the most proximal of the two distal pin sites; Figure 14 reveals the extent of bone loss following multiple sequestrectomies.

served in this position and some of them loosened. Recently the technic has been modified to the point where additional pins are placed in the proximal femur and distal tibia as well. A much more solid fixation can thus be obtained.

**CASE VI. Maintenance of limb length in extensive bone loss:** Illustrated in Figures 8 to 14 is the case of a thirty-seven year old switch tender who was struck in the left arm by a railroad engine in 1941. There was marked soft tissue and bone loss. The patient almost died of hemorrhage. This prevented immediate definitive treatment. Severe infection developed and when this subsided a plaster shoulder spica was applied which the patient wore for seventeen months. A radial nerve palsy which developed immediately after injury was treated with physical therapy and cleared up during this time. Five months after all drainage had subsided the cast was removed, skeletal pins inserted and fixed and an intramedullary tibial graft put in place. The solid fixation in proper position made this procedure much easier than

it would have been on a flail arm. The patient wore the apparatus for nineteen months without any discomfort or complications before it was believed that the arm was solid enough to remove all protection. He did his regular work during the greater part of this time. Due to the great soft tissue loss there was no muscular protection for the bone. This fact was brought to our attention time and time again. Since the patient was an alcoholic, he exposed himself to unnecessary situations such as tavern brawls and strong arming. The humerus has been fractured on five occasions since the grafting procedure. Police have taken him to the nearest hospital for treatment but the next day he always reports to us to have skeletal pins with external fixation applied. He much prefers it to a cast. With this form of treatment he is able to continue on his job. Because approximately the same pin sites were used on all occasions it became difficult to find solid cortex to hold the pins. On the last fracture it was thought that an onlay iliac bone graft might speed his recovery.

The thin layer of soft tissue proved a stumbling block. It was closed without tension over the graft but the circulation was poor and a slough occurred. Even a skin flap from the chest wall to cover the soft tissue defect did not take entirely. The bone graft was quite solid by the time soft tissue healing was obtained. But osteomyelitis developed in all the pin holes. The patient treated it himself for months. He reported for examination in June, 1948, and a sequestrectomy of all pin holes done. His progress has been satisfactory to date. Such a case as this seldom occurs in a life time of practice. The insertion of pins in the same area should probably not be done more than two or three times. But this patient so preferred skeletal pinning to the cast he had worn that it influenced our better judgment.

#### COMMENT

Few surgeons today advocate just one method of treatment for all types of fractures. Those who do arouse justifiable criticism. Such criticism may become so intense as to blind most surgeons to its merits even when indicated.

The great majority of fractures can be treated by the time honored closed reduction methods, namely, manual reduction and immobilization by cast or splints. The minority of fractures, the so-called selected cases, must be met by special methods: skeletal traction, open reduction and internal fixation by plate or screws, or bone grafting. These methods all necessitate prolonged bed rest or further immobilization by casts. The author contends that in certain of these selected cases skeletal pinning and external fixation is preferable. It offers an excellent method of securing healing

with a minimum of inconvenience to the patient and with no greater danger of complications than exists in the aforementioned reduction procedures.

Infections either in the bone or the soft tissues are the bugaboo of all open reductions. Those surgeons who have mastered the "Lane technic" have reduced infections, not completely, but to a minimum. Some of these, confident of their ability to avoid complications, advocate plating or screws in many fractures in which the majority still secure good results by the closed methods. A few surgeons have equal confidence in their ability to avoid complications with the use of skeletal pinning and external fixation. These likewise have mastered the technic which minimizes infections. Both groups in their enthusiasm often give the impression that their methods are indicated in the majority of fractures.

The author emphasizes the value of closed reduction and simple immobilization for the majority of fractures. The merits of open reduction and fixation of the fragments by plate or screws when indicated are recognized. It is pointed out that there is a definite place for skeletal pinning and external fixation in certain selected cases.

#### SUMMARY

Arguments for and against the use of skeletal pinning and external fixation are discussed. Its use in certain selected cases is advocated. Illustrative case reports are presented.



# ARTHRODESIS OF THE ANKLE JOINT\*

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**A**RTHRODESIS has proven of value in relieving the disabling symptoms of paralytic deformities, traumatic arthritis and advanced infections involving the ankle joint. This was emphasized in an early follow-up of ten patients who had ankle arthrodeses between the years 1942 and 1945 in the Department of Orthopedic Surgery at the Hospital of the University of Pennsylvania.

The admitting diagnoses included five patients with residual paralytic deformities from anterior poliomyelitis, three patients with chronic arthritis following trauma and two patients with chronic infections, one of these tuberculosis.

Of the five patients with paralytic disabilities, there were four with extensive paralytic involvement of the entire extremity as well as the local complaint of flail foot. One had subluxation of the ankle joint with associated pain on weight-bearing. In the other four pain was not a complaint. Their chief indication for treatment was limitation of function and pronounced deformity. Three of the five paralytic patients needed further stabilization of the foot. Two had triple arthrodeses previous to ankle fusion, one a subastragalar arthrodesis at the time of ankle fusion and one had a talonavicular arthrodesis previous to ankle fusion and one at the time of ankle fusion.

The three patients with a diagnosis of traumatic arthritis complained chiefly of pain and marked restriction of motion. Three patients had previous fractures involving the ankle joint with healing in poor position; one, twenty years; one, two years; and one, four months previous to admission. Symptoms in these cases had

arisen shortly after mobilization was begun and had increased with activity.

Two patients had severe osteomyelitis. In one of these the osteomyelitis resulted from a hunting accident in which a shotgun was discharged into the lower leg and ankle joint region ten months prior to admission, with a resultant comminuted compound fracture. The other case was that of a tuberculous infection of ten years' duration, with pain and marked destruction of the articulating surfaces.

A similar operative technic was followed in the ten cases. Under tourniquet a longitudinal midline or anterolateral incision was made. The periosteum was incised exposing the distal tibia, ankle joint and astragalus and the entire articular cartilage of the upper surface of the astragalus, tibia and fibula was cut away. Moderate deformity of the ankle joint was corrected at this time by adequate excision of bone from the apposing surfaces. Recesses which may remain following this should be filled with bone chips obtained when the tibial graft is taken. A full-thickness cortical graft approximately 1 inch wide and 2 inches long was removed from the tibia immediately above the joint surface. A gutter of suitable dimensions was cut from the anterior portion of the body and the superior surface of the neck of the astragalus. With the tibia and astragalus in proper alignment, the graft was moved across the anterior surface of the joint and counter-sunk into the prepared gutter in the astragalus. The wound was closed in layers followed by the application of a plaster cast maintaining the foot in proper equinus and the knee in moderate flexion. Equinus of 12 degrees beyond a right angle is con-

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sidered adequate for males unless compensation for unequal leg lengths is necessary. More equinus is indicated in the

equinus. This was determined by the angle formed by a line drawn on the roentgenogram through the longitudinal axis of the

TABLE I

Patient and Age	Diagnosis	Symptoms	Operation	Complications	Weight-bearing (mo.)	Bony Fusion	Function	Cosmetic
I. J. C., 36	Paralytic equinovarus	Pain on weight-bearing, instability	Triple arthrodesis 1/10/45, ankle fusion 1/24/45	None	3	Yes	Excellent	Slight residual forefoot varus
II. G. F., 15	Paralytic flail foot	Instability	Ankle fusion talonavicular fusion 3/14/45	None	6	No	Good	Good
III. B. F., 17	Paralytic flail foot	Instability	Ankle fusion astrag-scapoid 11/30/42, subastrag-fusion 1938	Wound infection	14 as other procedures necessitated bed rest	Yes	Good	Good
IV. E. C., 18	Paralytic flail foot	Instability	Ankle fusion 9/23/42	None	3	Yes	Good	Good
V. H. H., 39	Paralytic flail foot	Instability	Triple arthrodesis 6/23/44, ankle fusion 1/3/45	None	3	Yes	Good	Good
VI. W. W., 54	Traumatic arthritis following fracture	Pain, limitation motion	Subastrag. and ankle arthrodesis 9/29/43	Wound infection	4	Yes	Good	Good
VII. O. J., 50	Traumatic arthritis following fracture dislocation	Pain, limitation motion	Ankle fusion 4/19/44	None	3	Yes	Good	Good
VIII. P. M., 53	Traumatic arthritis following fracture dislocation	Pain, limitation motion	Ankle fusion 11/13/44	None	4	Yes	Good	Good
IX. O. A., 36	Osteomyelitis ankle joint from gun-shot wound	Pain, purulent discharge	Ankle fusion 10/18/44	None	4	Yes	Good	Good
X. E. K., 22	Tuberculosis ankle joint	Purulent discharge, pain	Ankle fusion 11/6/44	Fracture of donor site 4 mo. postoperatively	8	Yes	Good	Good

female, the amount depending on the height of heel to be worn.

Postoperative roentgenograms were used to determine accurately the degree of

tibia intersecting another line along the inferior margin of the os calcis extending to the inferior margin of the head of the first metatarsal. Correction of unsatisfac-

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tory position may be obtained by wedging the cast. For correction of inadequate equinus, the cast may be cut anteriorly over the ankle joint and the foot forced into more equinus. The wedge is removed posteriorly if more dorsiflexion is necessary. Accurate roentgenographic check of position is important as an awkward heel gait may develop if too little equinus is obtained. Excess equinus places strain on the forefoot.

Two months postoperatively the cast was removed for clinical and roentgenographic examinations of the ankle joint. If both examinations reveal satisfactory progression of the fusion, weight-bearing was begun in a snugly fitting plaster boot extending from the toes to the tibial tubercle. The sole of the boot was reinforced to withstand direct weight-bearing on the plaster. Nine of the ten patients began weight-bearing in plaster between two and three months postoperatively. After one month of weight-bearing in plaster the patient had his cast removed in order to allow further clinical and roentgenographic examinations. These examinations revealed adequate fusion in eight of the ten cases and the patients were permitted weight-bearing with no support other than adequate shoes. Of the two patients requiring a longer period of immobilization, one was that of a paralytic flail foot and this case obtained a fibrous union even after six months' immobilization following ankle fusion. However, the functional use of the foot was much improved. The other was that of tuberculosis in which weight-bearing was started at four months but immobilization was continued for eight months in an effort to obtain quiescence of the infectious process. In this case there was a fracture at the site of removal of the tibial graft. During the fourth month of the eight months' immobilization given this patient there was roentgenographic evidence of callus formation about the tibia at the site of the graft removal. The patient offered no complaints and there were no significant clinical find-

ings. Subsequent roentgenograms showed evidence of complete healing.

The postoperative course of the ten patients was uneventful except for two wound infections which responded to conservative therapy and caused no subsequent disability. Three representative cases are presented. The entire group have been summarized in Table 1.

#### CASE REPORTS

CASE V. A thirty-nine year old, white male had flaccid paralysis of the left lower extremity with resultant difficulty in walking and equinovarus deformity of the foot since an attack of anterior poliomyelitis when eight years old. On December 18, 1942, the patient suffered a fracture of the shaft of the left femur following a fall. Solid bony union in good position was obtained following closed reduction and immobilization in plaster. The patient returned to work on May 16, 1943. At that time muscle examination showed fair power in the hip muscles, no power in the muscles about the knee except a trace in the hamstring muscles and no power below the knee except a trace in the flexors of the toes. The foot was held in equinovarus. The right lower extremity was  $\frac{1}{2}$  inch shorter than the left. Due to difficulty in walking and deformity of the left foot the patient was admitted to the hospital for stabilization of the foot. On June 23, 1944, a triple arthrodesis was done. On January 3, 1945, an arthrodesis of the ankle joint was performed. The foot was placed in 15 degrees equinus. Weight-bearing in plaster was permitted two months postoperatively. Three months postoperatively roentgenograms showed evidence of bony union and weight-bearing in a shoe with a  $\frac{3}{4}$  inch sole and  $1\frac{1}{2}$  inch heel lifts was begun. One year postoperatively the patient was walking without a brace or support and had no complaints.

CASE VI. A fifty-four year old, white male with complaint of pain and stiffness in the left ankle gave a history of having had the foot run over by a loaded wagon twenty years before, with resultant pain and stiffness becoming worse in the last five years. Dorsiflexion was limited to 90 degrees and enlargement of the lateral malleolus was noted. Walking was limited by pain, stiffness and weakness. On September 29, 1943, ankle and subastragalar

fusions were done. The wound broke down postoperatively but responded to conservative therapy. A walking plaster was applied twelve weeks postoperatively and weight-bearing with no immobilization was started fifteen weeks postoperatively. Follow-up of one year found the patient symptom-free and walking four or five hours daily without complaint.

CASE IX. A thirty-four year old, white male had a gunshot wound of the lower third of the right tibia and the right ankle which he suffered December 23, 1943. The compound comminuted fracture had been treated elsewhere. When admitted July 6, 1944, the leg and foot were edematous, several draining sinuses were present and the patient had not borne weight. Roentgen examination showed fragmentation of the lower end of the tibia and fibula and numerous lead shots. There was marked demineralization of the bones. On October 18, 1944, an ankle fusion was performed. Penicillin was given pre- and postoperatively. A walking plaster was applied in two months and three and a half months postoperatively he was walking in a shoe. One year after surgery he complained of occasional pain when walking on rough ground. No evidence of activity of the osteomyelitic process was found.

#### SUMMARY

1. Bony fusion was obtained in nine of the ten patients including those with

tuberculosis and osteomyelitis. One operation for correction of paralytic deformity resulted in failure of fusion after six months' immobilization. However, the functional result is satisfactory as the corrected position is being maintained.

2. Cosmetic improvement was obtained in all of the cases. This was most marked in the cases of paralytic deformity in which stabilization of the flail foot resulted in a more normal appearance. The thickening and discoloration of the skin associated with an underlying arthritis were no longer present in the patients with traumatic arthritis. The two patients with chronic infection complicated by draining sinuses obtained bony fusion and healing of their sinuses.

3. Functional use of the foot was improved in all ten cases. The patients presenting paralytic deformities found this particularly true. Increased stability of the ankle joint meant either wearing a smaller type of brace or completely discarding it. The patients with traumatic arthritis who formerly were limited to walking short distances now were able to carry on their normal activities without difficulty.



# CRYPTOMENORRHEA\*

## CONGENITAL AND ACQUIRED

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**C**RYPTOMENORRHEA will occur whenever an obstruction exists in the genital tract below a functional endometrium or a pathologic process that causes bleeding. The obstruction may be congenital or acquired, complete or incomplete. The endometrium may menstruate in response to normal stimuli or the bleeding may be secondarily induced by estrogens.

Retention of the menses was known to the ancients but the descriptions are vague and incomplete. Ricci<sup>1</sup> in his researches into the history of gynecology provides the following information: Rhazes (850-923 A.D.), an Arab physician, in Book xxii of the *Continens*, recognized imperforate hymen for which he advised incision followed by daily coitus. Hildanus (1560-1634 A.D.) described three cases of imperforate hymen. One was in a girl of sixteen who once a month was seized with violent abdominal pains, fainting spells, headaches and occasional epileptic fits.

### EMBRYOLOGY

The forms taken by the congenital types of this disease are readily understood after a consideration of the development of the genital tract. The Müllerian ducts appear as invaginations of the celomic epithelium. The lower portions of these ducts fuse in the midline and form a solid cord which tunnels caudally through the mesenchyme and impinges on the posterior wall of the urogenital sinus to form the Müllerian tubercles. The cephalic, unfused portions of these ducts become the fallopian tubes while the fused caudal portions give rise to the uterus, cervix and the greater part

of the vagina. Failure to fuse at the proper level gives rise to the varieties of bicornuate uterus. Failure of fusion combined with persistence of the septum between the two ducts causes anomalies ranging from a small septum, as in the uterus subseptus, to complex anomalies such as uterus didelphys with a double vagina.<sup>2</sup> Arrest of the mechanism of proliferation and canalization can cause atresia at any level.

Investigators differ in their interpretation of the development of the lowermost portion of the vagina and hymen. The work of Koff<sup>3</sup> on the formation of the human vagina gives us a workable explanation of the later clinical findings. His investigations reveal the lower one-fifth of the vagina and the hymen to be derived from the urogenital sinus. Bilateral posterior evaginations of the urogenital sinus occur which obliterate the Müllerian tubercle. These are called sinovaginal bulbs and by proliferation of their lining epithelium and fusion they form, together with the lowermost portion of the fused Müllerian ducts, the primitive vaginal plate. The solid primitive vaginal plate grows in all directions while the central cells break down to form the lumen of the vagina. The hymen is composed of a posterior segment and anterior paired segments. The posterior segment is seen to arise from a bulbous expansion of the primitive vaginal plate. The anterior paired segments are formed from bilateral lips at the point of origin of the sinovaginal bulbs.

Imperforate hymen may be interpreted as occurring because of excessive proliferation and coalescence of the epithelium of the sinovaginal bulbs. Congenital retro-

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hymenal atresia probably arises from non-canalization of the lowermost end of the fused Müllerian ducts.

### ETIOLOGY

Cases of congenital origin provide the greater part of those reported in the litera-

TABLE I  
ETIOLOGY OF CONGENITAL CRYPTOMENORRHEA

	Literature 1926- 1946	Present Study	Total
Imperforate hymen.....	142	12	154
Congenital retrohymenal atresia.....	29	1	30
Congenital atresia of the vagina.....	26	2	28
Uterus bicornis unicollis, blind rudimentary horn.....	16	..	16
Uterus didelphys, double vagina, unilateral blind vagina.....	13	1	14
Uterus bicornis unicollis, unilateral blind horn.....	5	..	5
Uterus septus duplex, blind hemi-uterus.....	5	..	5
Uterus didelphys, rudimentary blind horns, gynatresia.....	2	..	2
Uterus bicornis septus, unilateral blind horn.....	2	..	2
Uterus bicornis duplex, unilateral blind vagina.....	2	..	2
Congenital atresia of the cervix.....	2	..	2
Total.....	244	16	260

1. The cases in the present study include those indexed over a fifteen-year period (1932-1947) in the Woman's Clinic of New York Hospital and the Woman's Hospital in the State of New York. One case is a private patient of Dr. W. E. Studdiford and one a patient of Dr. Byron Goff, New York, N. Y.

2. We wish to thank Dr. Albert H. Aldridge for making the records of the Woman's Hospital in the State of New York available to us in this study.

ture. Table I is not statistically significant and only indicates the fact that the rare type of case is reported in the literature. Common congenital types are imperforate hymen and congenital retrohymenal atresia. The distinction between these two anomalies is difficult but may often be made by location and histologic study of the occluding membrane. A hymen has stratified squamous epithelium on both sides. Patches of Müllerian duct epithelium may be recognized on the inner surface of

a membrane which is a true retrohymenal atresia, while the subepithelial layers contain muscle fibers, many blood vessels and lymphocytes.<sup>4</sup> Atresia of the vagina is a common cause although collectively more cases involving complex uterine anomalies have been recorded. Lateral hematocolpos

TABLE II  
ETIOLOGY OF ACQUIRED CRYPTOMENORRHEA

	Literature 1926- 1946	Present Study	Total
Agglutination of the labia minora.....	1	..	1
Vaginal Atresia Subsequent to:			
Laceration during childbirth.....	2	..	2
Non-specific adhesive vaginitis.....	2	..	2
Traumatic laceration of the vagina.....	..	1	1
Senile vaginitis.....	1	..	1
Gonorrheal vulvovaginitis.....	1	..	1
Burns from actual cautery.....	1	..	1
Syphilis of the vagina.....	1	..	1
Repair of high vesicovaginal fistula.....	1	..	1
Carcinoma of the vagina.....	1	..	1
Cervical Atresia Subsequent to:			
Cervical fibromyoma.....	6	1	7
Trachelorrhaphy.....	4	1	5
Intracervical radium.....	4	1	5
Laceration during childbirth.....	4	..	4
Dilatation and curettage.....	3	..	3
Senile atresia.....	3	..	3
Cauterization of cervix.....	2	..	2
Fibrosarcoma of the uterus.....	2	..	2
Postabortal endometritis.....	2	..	2
Chronic endocervicitis.....	2	..	2
Cervical stricture, cause unknown.....	2	..	2
Missed abortion.....	1	..	1
Total.....	46	4	50

and lateral hematometra are seen if a blind side exists in one or another type of didelphic or bicornuate uterus.<sup>5,6,7</sup>

The acquired disease results from some agent which causes occlusion of the cervix or stricture of the vagina. (Table II.) Infection caused by or following in the wake of the primary etiologic agent is an important factor. Agents destroying the epithelial lining of the vagina with subsequent adhesions between granulating surfaces cause some cases. Operative procedures on

the cervix and the use of heavy cautery tips may cause subsequent contracture of the cervical canal. Atresias of the cervix may cause retention of menstrual blood when castration has not been complete after improperly screened radium. As an indirect result of pregnancy, cases have been seen after abortion, missed abortion and lacerations of the cervix or vagina. Fibromyomas mechanically obstruct the cervical canal and are a common acquired cause. Atrophic changes which occlude the lower genital tract or cervix before the complete cessation of menstruation or subsequently induced estrogen bleeding will result in a retention of blood. In a rare case the labia minor were completely agglutinated from a vulvitis in childhood.

Cryptomenorrhea actually is a complication of some other lesion of the genital tract. A clearer picture of its frequency and etiology is seen from its occurrence over a one-year period in a large gynecologic service. During 1948 there were 1,966 admissions on the gynecologic pavilions of the Woman's Clinic of New York Hospital. During that year eleven cases of acquired hematometra were seen but no congenital cases. The acquired cases complicated the following diseases: carcinoma of the fundus, four; cervical myoma, three; after intracervical radium, two; carcinoma of the ovary, one; senile atresia of the cervix with estrogen induced bleeding, one.

The twenty cases in the present study, listed in Tables I and II, also show that the rare congenital lesions are recorded while the cases of acquired cryptomenorrhea have been indexed under primary disease only. Twelve cases of imperforate hymen were encountered, one of congenital retrohymenal atresia, two of congenital atresia of the vagina and one case in a uterus didelphys. The four cases of the acquired disease by no means indicate the true incidence, but Table II does give a rather comprehensive list of underlying lesions seen with this complication. Two cases are described in more detail:

CASE I. A fourteen year old white female complained chiefly of recurrent attacks of lower abdominal pain of seven months' duration. With each attack she experienced nausea, vomiting, dysuria, low sacral backache and constipation. She had never menstruated externally. Her past history revealed that at the age of three years the patient had fallen astride her crib with resultant laceration of the vagina and vaginal hemorrhage followed by a persistent purulent discharge. Vaginal examination revealed a thick, white, scarred septum 3 cm. above the hymen. There was a cystic fluctuant mass filling the pelvis. The uterus could be made out on top and to the right of the distended vagina. A combined abdominoperineal approach was used at operation. Two hundred fifty cc. of old blood were drained from the uterus and vagina, the septum excised and a right salpingectomy done for a badly involved tube with hematosalpinx. Her periods became regular and two subsequent vaginal plastics were done for cicatricial stenosis of the vagina at the ages of seventeen and twenty-three. She has subsequently had two full term pregnancies with deliveries by cesarean section.

CASE II. A sixteen year old colored female had had a steady stabbing pain in the lower abdomen every twenty-eight days for four years. She had never menstruated externally. There was periodic swelling of the lower abdomen and ankles. For six years she had had stress incontinence on laughing or sneezing. Enuresis had existed all her life. On examination there was a small rudimentary vagina with a common opening for urethra and vagina. The uterus and adnexa were not definitely outlined. Cytoscopy revealed the right half of the trigone to be absent. The bladder was of small capacity. An intravenous pyelogram showed a silent right kidney and a left pelvic kidney with irregular calyces. Exploration and dilatation of the blind vaginal vault resulted in the drainage of 90 cc. of old menstrual blood. She now has scant periods every twenty-eight days with relief of symptoms.

#### PATHOLOGY

Where the obstruction exists at the outlet as in congenital retrohymenal atresia and imperforate hymen, the onset of menstruation initiates a sequence of events that may ultimately involve the entire genital

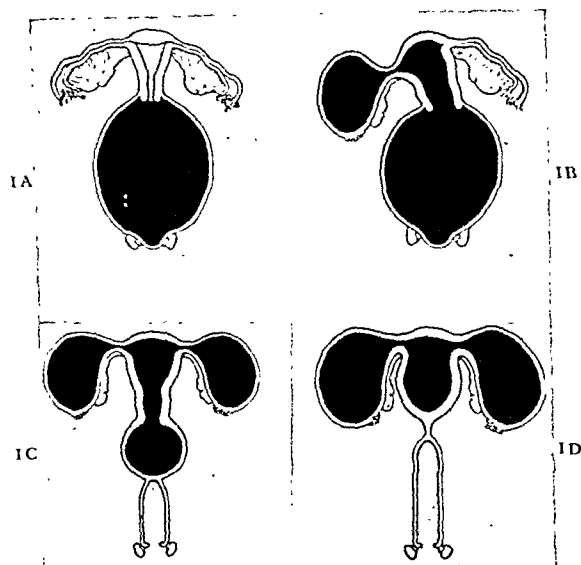


FIG. 1. Types of cryptomenorrhea; A, imperforate hymen, hematocolpos; B, imperforate hymen, hematocolpometra, right hematosalpinx; C, congenital atresia of vagina, hematocolpometra, bilateral hematosalpinx; D, congenital atresia of cervix, hematometra; bilateral hematosalpinx.

tract. Prior to the menarche the secretions of the cervical, uterine and tubal glands form a hydrocolpometra which may be insignificant in size or contain an appreciable amount of fluid. To this is now added the periodic menstrual flow. Fortunately, the vagina is very distensible and will hold a large amount of fluid before the retrograde distention fills and distorts the upper more vulnerable and permanently damaged uterus, tubes and ovaries. (Fig. 1A.) The contractile powers of the uterus spare this organ until late in the disease and in the moderately advanced cases the walls show hypertrophy due to the expulsion of the menstrual flow against positive pressure.<sup>7</sup> A laparotomy now would reveal the uterus perched on the dome of the hematocolpos.<sup>8</sup> The tubes, ovaries and cervix now succumb. The isthmic portions of one or both tubes may seal off; but if not, menstrual blood is forced into the tubes causing a hematosalpinx, on the peritoneum causing a hemato-peritoneum, and about the ovary resulting in a hemato-ovarium. Local reaction on the peritoneum seals the fimbriated ends of the tubes which expand and involve the surrounding structures in a tubo-ovarian cyst. The cervix effaces and

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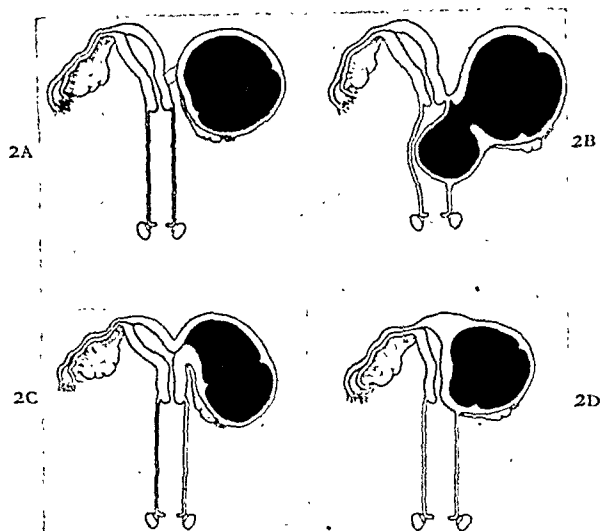


FIG. 2. Types of cryptomenorrhea; A, uterus bicornis unicollis, lateral hematometra in blind rudimentary horn; B, uterus didelphys, lateral hematocolpometra due to blind left vagina; C, uterus bicornis unicollis, lateral hematometra in blind left horn; D, uterus septus duplex, lateral hematometra in blind left uterine cavity.

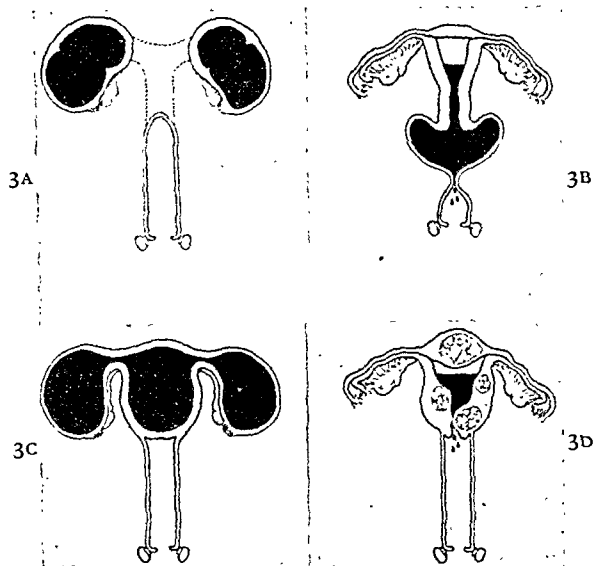


FIG. 3. Types of cryptomenorrhea; A, uterus didelphys, two rudimentary horns, hematometra due to gynatresia; B, acquired atresia of vagina, intermittent hematocolpometra; C, acquired atresia of cervix, hematometra, bilateral hematosalpinx; D, cervical fibromyoma, intermittent hematometra.

dilates causing a hematotrachelos. The uterus dilates and its walls become thinner and the glands compressed. (Fig. 1B.) Secretions and menstrual flow become less as the glands throughout the tract become atrophic and functionless. The process would be self-limited were it not symp-



FIG. 4. Bilateral hydroureter and hydronephrosis caused by a large hematocolpos.

tomatic long before reaching such an advanced state.

Where an obstruction exists at a higher level, multiple abnormalities of the genital tract are common. Above a vaginal or cervical atresia or in the blind horn of a bicornuate uterus, a functioning endometrium will menstruate and make exceedingly bizarre findings.<sup>9</sup> Not infrequently one uterus and vagina of a didelphic uterus is blind. Figures 1, 2 and 3 show several diagrams representing forms of the disease.

The acquired cases rarely obtain the large size of the congenital types since the disease is treated earlier and the level of obstruction is higher. (Fig. 3B,C,D.) The process becomes a pyohematocolpos or pyohematometra when partial obstruction allows an ascending infection from the vagina.<sup>10</sup> An intermittent hematometra or hematocolpos exists when an obstruction such as a cervical fibroid gives way periodically and drains.

#### COMPLICATIONS

The urinary tract is so commonly involved in this disease that urologic studies



FIG. 5. Left pelvic kidney with a silent kidney on the right; absence of the urethra and right half of the trigone of the bladder; congenital atresia of the vagina with a small hematocolpos.

should be done in each case. In low obstructions the expanding pelvic lesion may elevate and compress the bladder. With further increase in size of the hematocolpos, the ureters are spread wider apart as they course through the pelvis and the angle at which they enter the bladder is more obtuse. The pressure soon becomes sufficient to cause hydroureter and hydronephrosis. (Fig. 4.) The urethra may be compressed against the symphysis in addition to being angulated at the bladder neck. Complete obstruction can take place with enormous dilatation of the bladder. In high obstruction concomitant anomalies of the urinary tract are frequent. Duplication and malformation in the course of the ureters, ectopic kidney, bladder anomalies and the absence and duplication of the urethra have been reported.<sup>12</sup> (Fig. 5.) It is important in each case to demonstrate by cystoscopy and urography the course, number and relationships of the ureters.

The membranes seen in imperforate hymen and retrohymenal atresia are thick and tough and obviate spontaneous rupture. (Fig. 6.) Diverticulum formation or rupture into the rectum, bladder or ischio-

rectal fossa is possible.<sup>13</sup> Spontaneous amputation and rupture of a dilated blind horn is reported. Rupture of a large hematosalpinx with hemorrhage causes an abdominal catastrophe.

#### COMPOSITION OF RETAINED BLOOD

The composition and quantity of the retained blood depends on the duration of the disease and on the presence or absence of infection. As much as 3 L. have been drained in some instances. In the uninfected cases the retained blood is thick and dark, having the appearance of chocolate syrup. The longer the duration of the disease the more viscid are the retained products of secretion and menstruation due to the resorption of the liquid elements. In cases of short duration the cervical, uterine and tubal glands provide a proportionately larger part of the fluid. As the process becomes older and the tension within the vagina and uterus becomes greater, the glands of the cervix, uterus and tubes are compressed; and although they are recognizable histologically, it is unlikely they contribute an appreciable amount to the contents.

Histologically, the solid elements are red blood cells in all stages of disintegration, many living leukocytes and cast off cells of the uterus and vagina.<sup>14</sup> Mucin and pigments can be demonstrated. Lactic acid is present in large enough quantities to make the fluid acid to litmus. Specific determinations of the calcium and iron show them to be higher than in whole blood. An analysis of the fluid from one of our cases revealed the following values: non-protein nitrogen, 29; uric acid, 4.3; urea nitrogen, 17.8; chlorides, 11; sugar, 8; calcium, 9.4; total proteins, 5.9 and a pH of 7.5.

Cultures of the fluid are sterile in the congenital cases in which no drainage to the exterior has ever been effected. The cases with partial obstruction or recurrent hematometra are frequently infected and here the retained blood is more liquid, foul-smelling and often frankly purulent. Because of repeated replacement and drainage



FIG. 6. Imperforate hymen, hematocolpos.

there is little difference from menstrual blood but with the added factor of infection. Infection is present during the development of strictures in the acquired types of the disease whether it be the primary etiologic agent or not. Once sealed off the cavities may become sterile, as acquired cases of long duration are seen draining only retained blood and no pus.

#### SYMPTOMATOLOGY

Periodic pelvic pain, failure to menstruate and dysuria form a triad of symptoms suggesting an expanding pelvic lesion, such as hematocolpos, from obstruction at the outlet. The failure of the menarche to appear is not the most common primary complaint that brings the patient to the doctor as many mothers just consider their daughters late.<sup>15</sup> Occasionally the urinary symptoms dominate the picture and are the primary complaint. The pain due to vaginal distention is a dull ache in the perineum and sacrum which is increased by sitting and defecation. Painful hemorrhoids may exist from pressure on the rectum. Menstrual molimina often recur at monthly intervals associated with nausea, vomiting and vertigo. At cyclic intervals an acute hypogastric pain, as in severe dysmenorrhea, may be added. Acute lower abdominal pain, as in pelvic peritonitis, suggests a hemoperitoneum.

Dysuria is the most common urinary complaint. With increasing obstruction the patient may complain of frequency and the stream becomes progressively smaller and



less forceful. Abdominal pressure may be used to start the flow. An attack of complete retention first brings the patient to the physician in a surprising number of cases. With the development of a hydro-nephrosis, flank pain may be a symptom.

In cases of high obstruction of congenital origin, no set pattern of complaints is discernible. Primary amenorrhea, vague pelvic pain, attempts at coitus in cases of vaginal atresia, urinary complaints, dysmenorrhea in cases of lateral hematocolpometra, sterility or the appearance of an abdominal swelling prompt these patients to seek medical advice. The symptom complex in a given case depends on the extent, duration and location of the expanding lesion.

The patients with acquired lesions are seen early because they have usually been under treatment for a pelvic complaint prior to the development of an obstructive lesion. Secondary amenorrhea, pelvic pain or intermittent passage of old blood and pus are the common complaints. The urinary tract is not involved as a rule and does not give rise to symptoms. Patients frequently date the onset of the process and suggest the cause.

#### DIAGNOSIS

With a large hematocolpometra from obstruction at the outlet a tender suprapubic mass can be palpated. This mass frequently rises to the umbilicus or above. An imperforate hymen spreads the labia minora and presents a bulging, dusky membrane. (Fig. 6.) An impulse created by percussion of the abdominal tumor is transmitted to the hymen and perineum. This abdominoperineal fluid wave is, in our experience, pathognomonic of a large hematocolpos. Coughing also produces an impulse on the bulging membrane. Rectal examination reveals the distended, tense vagina filling the pelvis. Following aspiration the thickness of the occluding membrane can be roughly estimated by palpation between the rectal and external finger. On combined recto-abdominal examination an outline of the pelvic organs may be obtained. It is

of primary importance to determine the extent of involvement of the uterus and tubes. With the vagina alone involved, the uterus may at times be felt sitting on the dome of the distended vagina. With advanced adnexal involvement, boggy, painful masses may be felt in one or both adnexal regions.

The membrane of retrohymenal atresia may frequently be distinguished from an imperforate hymen on gross inspection. The former is thinner and the hymen itself may often be seen exterior to and stretched on the anterior perimeter of a bulging retrohymenal membrane.

Palpation and inspection will disclose atresias of the vagina and cervix with a pelvic mass above. A bulging mass can be felt on the affected side of the vagina with a lateral hematocolpos. Under strictly aseptic conditions an exploratory needle may be passed into the fluctuant mass and the characteristic fluid withdrawn. The latter may now be replaced with an equal amount of radiopaque media and x-rays taken to give further information on the anomaly.<sup>17</sup>

Acquired atresias are seen in the upper one-third of the vagina. Probing may reveal a partial atresia and allow the escape of blood and pus. Acquired cervical atresias that are complete present a bulging, fluctuant tumor of the vaginal vault. The cervix is effaced and careful inspection reveals a dimple or linear depression at the location of the external os. The exploring needle should enter at this point. Where partial obstruction exists, probing will usually reveal the nature of the disease.

So few cases are seen by anyone that mistaken diagnoses are common. A careful pelvic examination, if necessary under anesthesia, will reveal the true nature of the obscure case. The amenorrhea and a pelvic mass frequently leads to a diagnosis of ovarian neoplasm. Appendicitis and ruptured ectopic pregnancy can be closely simulated by a hemato-peritoneum. The symptom complex of recurrent monthly pelvic pain together with amenorrhea will alert one to the possibility of hidden men-

struation and prompt a search for a source of obstruction or the presence of genital anomalies.

#### TREATMENT

The treatment of imperforate hymen and retrohymenal atresia is identical. The patient is prepared for both perineal and abdominal operations and a recto-abdominal examination under anesthesia is performed to determine if a hematosalpinx exists. If no adnexal involvement is evident at this examination, a few cubic centimeters of old blood are aspirated by needle and syringe to confirm the diagnosis. Further procedures are deferred until the following day as it is desirable to have the patient awake for the hymenotomy. Local anesthesia is used in order that the patient may report any signs of intraperitoneal hemorrhage from an undetected small hematosalpinx. A cruciate incision is made in the membrane, the quadrants excised and the edges approximated with sutures of fine catgut.<sup>18,19</sup> This prevents future closure or rigidity of the hypertrophic membrane. Suprapubic pressure is not used to hasten drainage nor is the cervix visualized at this time. The prophylactic use of antimicrobials is recommended prior to operation and for several days postoperatively until the profuse drainage of old blood ceases. Irrigation of the vagina or the use of drains can only be condemned as inviting infection. The patient is placed in Fowler's position and can be mobilized early if her course is normal. Frequent vaginal examinations are avoided until after the first menstrual period unless indicated earlier by persistence of symptoms or other developments. Involution of the tract requires several months and the first few menstrual periods may be abnormal. No douches, coitus or swimming should be allowed until involution is complete. The genital tract is studied by low pressure uterosalpingograms using a small quantity of contrast material several months postoperatively. Residual damage and tubal patency are determined.

The examination under anesthesia may reveal adnexal involvement. In this event laparotomy is performed prior to hymenotomy in order to observe the drainage abdominally. The dangers of an intra-abdominal hemorrhage are very real. The sudden release of pressure with contraction of the uterus can tear adherent tubes away from the pelvic wall or rupture vascular adhesions.<sup>20</sup> All bleeding is controlled and only hopelessly diseased organs removed. The tubes are milked of old blood and the adhesions at the fimbriated ends are gently separated. While many tubes might empty spontaneously,<sup>21</sup> it is not believed that expectant treatment is indicated in cases with a hematosalpinx.

Atresias of the vagina and cervix are explored from below and a canal created from the apex of the blind vaginal vault to the lower pole of the pelvic mass. An assistant's finger in the rectum and a sound in the bladder serve as guides. The combined approach is indicated when exploration from below is unsuccessful or the pyelograms indicate an anomaly of the ureters in the field of operation. A hysterotomy is performed, the old blood evacuated and the anomalous ureters visualized. A finger is then placed in the cervix or lower pole of the uterus and used as a guide for an assistant to dissect on from below. Alternately dissection may be done from above on the assistant's finger below. The newly formed canal is kept open by insertion of glass dilators or a formed balsa wood plug beginning in the early postoperative period.

Lateral hematocolpos is treated by complete excision of the septum between the blind and patent vaginas if such anomaly exists. Simple incision should not be done as secondary closure is common. A laparotomy is performed for the anomalies that do not lend themselves to vaginal drainage. A hemi-hysterectomy, excision of an atretic horn or rarely a hysterectomy may be indicated.

Treatment of acquired cryptomenorrhea involves the re-establishment of the con-

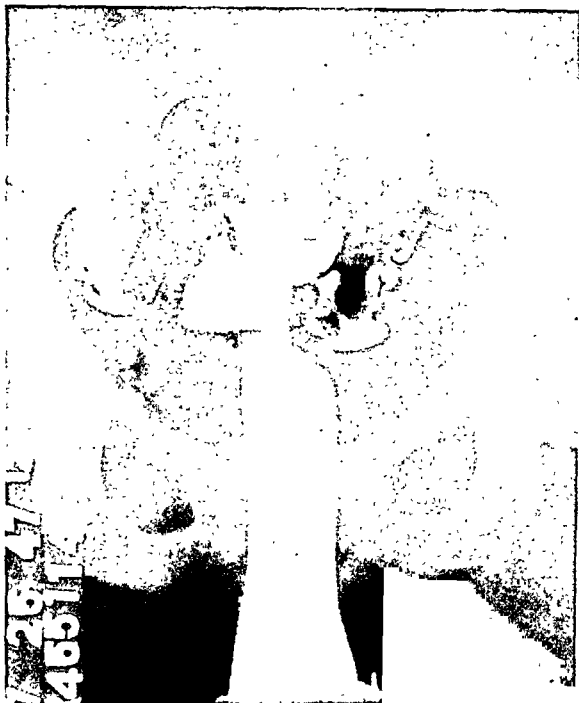


FIG. 7. Normal uterus and patent tubes ten months after drainage of a large hematocolpos.

tinuity of the vagina or cervix and subsequent measures to insure patency. The dissection is easier than the congenital types as the relationships of the bladder and rectum are normal. Infection will respond to adequate drainage but is resistant to treatment if partial obstruction remains. The denuded areas of the vaginal cases are separated daily while healing. The cervix is dilated as often as necessary to assure a patent canal. Rarely a modified Pozzi operation is needed to evert the external os. Further surgical procedures, indicated because of the etiologic agent, are preferably deferred until the infection is controlled.

Patients with congenital cryptomenorrhea require special guidance to prevent the normal psychic trauma of the menarche from becoming pathologic. The anxiety connected with the onset of menstruation is exaggerated when the adolescent girl finds her menstrual function is abnormal.<sup>22</sup> The patients with uncomplicated hematocolpos should be reassured and given an adequate explanation of the amenorrhea. Should pregnancy fantasies exist these are dispelled. As optimistic a prognosis

as is compatible with the findings should be given regarding menstruation and reproduction.

Those patients with abnormalities having a poor prognosis may react acutely to the discovery of an anomaly. The questions of marriage, sexual compatibility and sterility will arouse marked anxiety in a young woman normally much concerned with these events. The tendency to devalue herself after becoming aware of her affliction may cause serious conflicts. A profound neurotic disturbance may threaten, requiring prolonged psychotherapy for which a psychiatric consultant should be sought.

#### PROGNOSIS

The uncomplicated hematocolpos is cured by hymenotomy with return of the genital and urinary tracts to normal. (Fig. 7.) Menstrual difficulties are usually not seen after the first few periods and the urinary tract suffers no permanent damage. Later pregnancies have been regularly reported when the disease has been confined to the vagina. The prognosis is not good when a large bilateral hematosalpinx is found as the salpinges suffer permanent damage. Many cases reported as sterile in later life had some form of irrigation or packing used in the treatment.

Individual prognostication, based on the structures that can be spared at operation, must be made in the case of the various anomalies. The anomalies of duplication with unilateral involvement lend themselves to operations that spare some healthy ovarian and endometrial elements. In general, the prognosis here is good regarding the relief of symptoms but poor in regards to pregnancy. The acquired disease responds favorably when the infection is controlled. Recurrences must be guarded against by periodic examinations.

#### CONCLUSIONS

1. Occlusion of the genital tract is infrequent despite the vast amount of surgery and cauterization that is performed.

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2. The urinary tract is involved so frequently in these diseases, either because of concomitant anomalies or because of compression by the pelvic mass, that urologic studies and follow-up should be done in each case.

3. The use of prophylactic penicillin and sulfadiazine reduces the risk of infection and improves the prognosis regarding tubal patency.

4. The combined abdominoperineal approach should be used when the tubes are involved or when anomalies of the ureters make them liable to injury during any operative procedures from below.

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# TECHNIC OF PRESACRAL NEURECTOMY

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THE resection of the pelvic sympathetic plexus, which I did for the first time in 1925 as a treatment of dysmenorrhea, is already accepted in all countries of the world. Since 1925 I have extended the indications of this resection to the treatment of vaginismus, pelvic neuralgias, resistant vulvar itch and some cases of genital superexcitement. However, if one judges the articles published on that subject, the results are not always as they are expected to be; some surgeons claim that only 50 of 100 patients have been cured.

Personally, in over 1,500 patients seen in a period of twenty-two years I count only 2 per cent who were not cured by the operation. These patients are classified as having dysmenorrhea caused by a psychic or a physical defect which this operation could not improve.

If we closely analyze the articles published by some surgeons with regard to their lack of success in that operation, we can say without hesitation that their results are the consequence of a defective technic.

In our first operations, which gave us good results, we looked on the presacral lamina for some nervous strings the way anatomists taught us. In 1926 we reported that it was necessary to do a radical resection of all the fibro-cells of the lamina in which the elements of the superior hypogastric plexus lay and which contained more or less important nerve cells and numerous ganglionic tissues.

Several times we heard from foreign surgeons that they had never done such radical operations as the ones we did in their presence. Afterward, using our technic in this operation, those surgeons had good results which were comparable to ours.

## TECHNIC

Technic being the important question for good results, it is important for us to give all the details:

1. *Anesthesia.* Spinal anesthesia, 12 or 15 mg. of novocain, is our preference. It produces good abdominal relaxation and, the patient being in Trendelenburg position, it is easy to reach the promontory.

2. *Incision of the Abdominal Wall.* Very often we do a low Pfannenstiell incision so that the cutaneous scar will be hidden by the pubic hair. This incision, however, needs careful control of bleeding.

The abdominal aponeurosis must be incised at least 3 or 4 cm. higher than the cutaneous incision. Otherwise it would be difficult to reach the body of the fifth lumbar vertebra in front of which one must find the presacral nerve.

3. *Intraperitoneal Maneuvers.* At first one must closely examine the internal genitalia in case any lesion is present which could be so small as to be overlooked by a clinical examination before operation. One may discover slightly diseased ovaries or little foci of endometriosis or adenomyomatosis of the cornua, etc. It is almost always possible to treat such small lesions by conservative operations if one does the resection of the presacral nerve afterward. Sometimes these lesions are sufficient to explain the dysmenorrhea and, even if their excision would cure those patients, I have always insisted that one do the resection of the presacral nerve in cases of dysmenorrhea because most often these lesions of the genitalia are not included in the pathology of menstrual pains.

4. *Resection of the Pelvic Sympathetic.* It is on the body of the fifth lumbar vertebra slightly above the promontory that the nerve is the most easily accessible.

It is important to see the promontory very well for it is *the first anatomic point to remember*. Above and slightly outside of the promontory the two primary iliac arteries, which are lying immediately under the peritoneum, form a triangle with an inferior base and the apex is formed by the division of the aorta. This forms *the second anatomic point to remember*. In this area, which will be more visible if one reclines the pelvic colon, one will see, a little outside of the middle line at the left, the inferior mesenteric artery which runs in the mesocolon near its insertion line.

We always cut the peritoneum vertically. This permits us to make a longer incision up and down if we decide to do a more or less important resection of the pelvic sympathetic. (Fig. 1.) Generally we are satisfied with an incision 4 to 5 cm. long, the middle of which should correspond to the promontory. Retracting the two lips of the peritoneal incision, one can see forward to the spine a cellulofibrous mass which covers the body of the vertebra. In this cellulofibrous mass the pelvic sympathetic lies (superior hypogastric plexus of Hovelacque). (Fig. 2.)

To perform a good resection of that plexus it is important before cutting it to dissect the presacral lamina cleanly on its sides. To do this, either with the tip of long scissors or with a dissector of Leriche, one has to separate the edges of that fibrous lamina. (Fig. 3.) Anteriorly the lamina has been separated from the peritoneum already. On its edges this lamina is mixed with subperitoneal cells but on the right side it is easy to recognize the edge of the fibrous lamina in which the sympathetic nerve lies. The posterior part of the lamina is also easy to separate. Usually the medium sacral vessels remain adherent to the skeleton. On the left side the mesenteric vessels may be troublesome but one has to be careful not to injure them.

In certain cases the primary root of the mesocolon has its insertion on the median line making it more difficult to reach the promontory. If this condition exists, we

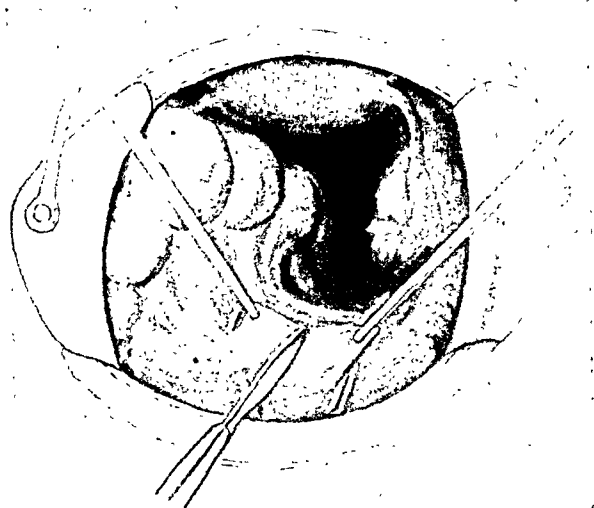


FIG. 1. Incision of the posterior peritoneum lifted up in front of the fifth lumbar vertebra.

always make our incision of the posterior peritoneum 1 cm. outside the median line. Retracting the left lip of that peritoneal incision, we push aside the mesenteric vessels and usually the anterior part of the presacral lamina is easy to dissect.

To have a better dissection of the fibrous lamina in which the nerves lie, we use as a rule the Deschamps needle which is introduced in the hole made on the right side. This needle is used to dissect the left side by pushing away the mesenteric vessels. (Fig. 4.)

If we lift up the presacral lamina with a Deschamps needle at the level of the fifth lumbar vertebra, we see that it becomes wider as it passes the promontory and then takes a triangular form with its apex up. (Fig. 5.) This is the cross section of the presacral nerve from which the two hypogastric nerves proceed to the two corresponding ganglions (inferior hypogastric plexus of Hovelacque).

The nerve being lifted up, it is easy to finish its dissection upward and downward. Before cutting it is very important to be sure that the whole nerve will be cut and not just one of its branches right or left. For this reason it is very important to see the angle of the cross section where the presacral nerve gives birth to the hypogastric nerves. If only one of the two nerve cords is seen, the reason is that only half



FIG. 2

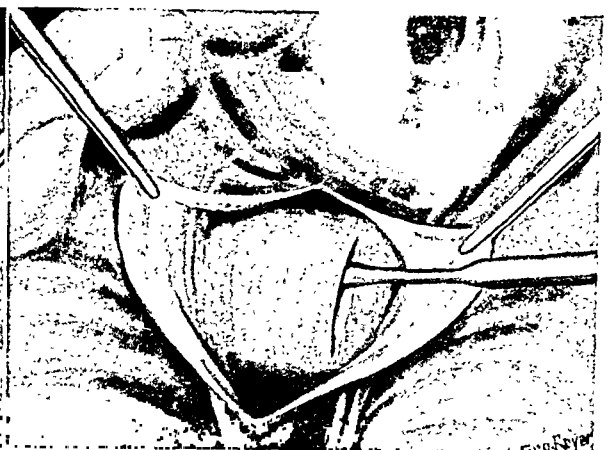


FIG. 3

FIG. 2. Retraction of the peritoneum to give a clear view of the presacral lamina; on the left are the mesenteric vessels in the base of the mesosalpinx; on the right is the ureter after crossing the hypogastric vessels.  
 FIG. 3. Separation of the presacral lamina on its right side.

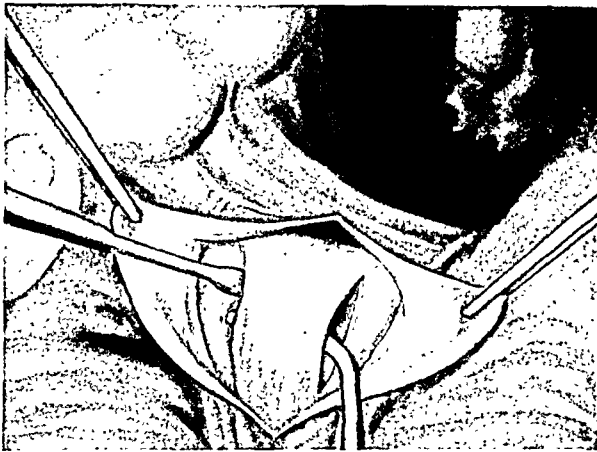


FIG. 4

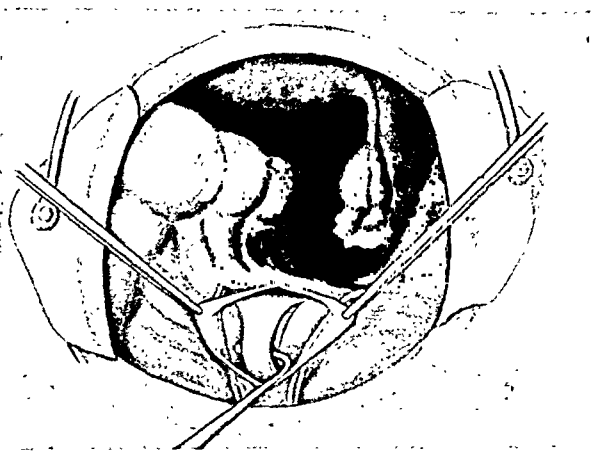


FIG. 5

FIG. 4. Separation of the presacral lamina is performed with a "Deschamps needle" and a dissector.  
 FIG. 5. The entire lamina is lifted up with a curved, smooth-edged needle before being widely resected. Note the triangular shape formed by the hypogastric nerves which prolong it.

of the presacral nerve lies on the needle. Then it is important to find and dissect the other half. It is very useful to have at your disposal two Deschamps needles, one right-handed and one left-handed. Before cutting the lamina with a soft instrument such as the handle of a Deschamps needle, we break the few afferent branches which come from the two last lumbar ganglions or the first sacral ganglion.

Usually we cut a length of 2 to 4 cm. of the nerve. The lamina in which the nerve lies contains only small blood vessels (*vasa vasorum*). Therefore, it is useless to tie both ends. We even think that tying the lamina is a cause of pain. If there is slight

bleeding, pressure for a while on the lamina along the spine will control it. The use of electrocautery to cut the presacral lamina will prevent this bleeding.

The left primary iliac vein is behind the sectioned lamina. It is almost always a little higher than the point where the presacral lamina is liberated practically where there is no danger of hurting it. The ureters are more outside. If the surgeon is on the left side, it is very easy to localize the right ureter. Only once did we accidentally hurt the left ureter which was very near the insertion of the pelvic mesocolon. This had not been dissected properly.

The nerve being cut, we suture the posterior parietal peritoneum. The latter is so loose that it may be closed with a purse string suture.

If the uterus is movable and, even more if it is retroverted, we complete the operation by fixing the ligaments using the method of Doleris-Gilliam-Pellanda. It is done to prevent scar retraction of the uterosacral ligaments and a secondary retractile parametritis in case there would be a slight serosanguineous exudate.

5. *Closure of the Abdominal Wall.* This procedure offers nothing in particular. However, it has to be done very carefully so that the anatomic reconstruction will be as perfect as possible.

6. *Postoperative Results.* There is usually no incident. We have never noted any immediate disturbances which were due to the sympathectomy. There is no urine retention and micturition is often much easier after than before the operation.

In over 1,500 operations we never saw any major accident. In only two cases was there slight bleeding of the posterior peritoneum on the first postoperative day so we had to re-operate and repair the posterior peritoneum. In two other cases there was an infiltration of blood in the sub-

peritoneal tissues which infiltrated in the posterior region of the rectum but was spontaneously absorbed. Before closing the posterior peritoneum, one must be sure of perfect control of bleeding. It is to be noted that these patients need three or four injections of morphia on the first day on account of their postoperative pains. Phlebitis and pulmonary infarcts are rare and do not exceed 1 per cent, due to the fact that the patients are young and free from any visceral diseases.

We have never noted any later disturbances among our patients. There were numerous women who had one or more absolutely normal pregnancies afterward. Women suffering from dyspareunia now have normal coition. We never saw a case of frigidity following the operation.

Symptoms may recur but that has been the exception; we count only 2 per cent of them. In all cases the symptoms existing with dysmenorrhea, namely, fever, vomiting, intestinal cramps, etc., clear up simultaneously.

We did the first resection of the presacral nerve twenty-three years ago and we can definitely affirm that, until now, no other method of treating dysmenorrhea has given such consistent good results.





# RECENT EXPERIENCES WITH THE CORKSCREW BOLT IN FRACTURES OF THE HIP\*

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ALMOST ten years have elapsed since the report of our early experiences with the corkscrew bolt.<sup>1</sup> Many difficulties had been encountered with the manufacture of the instrument and with its technical application and these problems were stressed in that early report. It was the general impression at that time, in spite of Kellogg Speed's warning, that the fractured hip problem had been solved quite adequately by a wide variety of instruments. New devices and techniques seemed unnecessary and interest in the corkscrew bolt's development lagged accordingly.

The broadened experience of subsequent years with all types of internal fixation failed to support our complacency. Although even the most recent statistics are at a wide variance, almost all agree that the proportion of unsatisfactory results continues high and that slipping and non-union play a significant role in the failures. Many operations have been designed for the relief of ununited hips. For their prophylaxis, however, only the current practice of many surgeons of prohibiting all weight-bearing until x-rays show evidence of bony healing has evolved. It is hardly necessary to point out how costly in time and how poorly tolerated this practice can be for the elderly patient. The prolonged inactivity it entails is a common cause of rapid and irreversible mental and physical deterioration.

Dissatisfaction with our results as well as those of others prompted us some four years ago to restudy completely the non-union problem with specific reference to compression-fixation, a principle which

held our confidence. The failures of others that had come to our attention as well as our own failures were carefully reviewed and the corkscrew bolt and its application again was subjected to careful analysis. The present report is based upon this study and the encouraging application of its result in the therapy of our subsequent intracapsular fractures.

## NON-UNION

The quest for a solution of the problem of non-union of the hip entails, first, a clear concept of what is required of hip fixation. For reasons that are not obscure, the intracapsular hip fracture presents more obstacles to healing than any other common fracture. Aside from its unique vascular properties, to be discussed later, the lesion from the outset is bathed continually and on all sides in joint fluid so that fracture hematoma is washed away as soon as it is formed. Fractures in this area also possess the unique misfortune of being directly antagonized by both muscle pull and weight-bearing. These forces, instead of aiding to keep the fracture ends against each other, pull crosswise, almost parallel with the plane of the fracture, and develop a shearing rather than compression stress as Pauels has emphasized.<sup>2</sup>

When the power of these forces is sufficient to overcome the fixation strength, the fragments move with reference to each other and, as the head sinks, the verticality of the fracture plane is increased. This further compromises the opportunity to heal. Still more motion pulls the fracture surfaces past each other so that even contact is lost. Because of the consistent

\* Read before the Orthopedic Section of the New York Academy of Medicine on March 19, 1948.

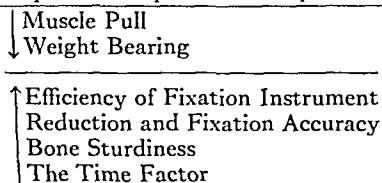
direction of this position slip, a hip fracture can be safely termed ununited quite early at a stage when most fractures would be properly considered as the site merely of delayed union.

Counteracting these tangential forces and in precarious equilibrium with them is the fracture fixation, the efficiency of which is quite variable and the result of several components. Important variables include accuracy of the specific reduction, accuracy of the instrument insertion and, of even greater importance, the strength and texture of the fractured bone.

Even the efficacy of the fixative instrument cannot be regarded as constant since its grip varies widely with the porosity of the bone through which it is inserted. Although most hip fractures occur in bone that is the site of some osteoporosis, its degree is subject to marked individual variation.

To be recognized also is the fact that *all* fixative devices are interval supports only. Even when perfectly applied through strong bone, none is capable of holding indefinitely. They are able to hold only until the reasonably prompt takeover of reparative tissue. If this fails to develop with normal speed, weakening of the fixation, rarification and slipping are prone to occur. It is necessary, therefore, to add the time dimension to the aforementioned static elements, the factors which are known to delay healing although they do not weaken the primary fixation.

#### Postoperative Hip Fracture Equilibrium



Ample experience supports the belief that healing will practically always follow fixation with standard instruments properly executed and through solid, healthy bone. Conversely, there is evidence that *the margin of safety is small* and that devia-

tion from accuracy in the controllable factors is promptly reflected in the results. Excellence in one variable can compensate in some measure for deficiency in another. Firm fixation through strong bone, for example, can overcome the weakness of

TABLE I

Non-union Mechanical Weakness	Delayed Healing	No. Cases
A. Instrument		
1. Poor reduction or application.....		5
2. Extrusion of nail, wandering.....		1
3. Diastasis.....		1
B. Host		
1. Fracture obliquity (early).....		?
2. Excessive muscle pull..... (spasticity, etc.)		1
3. Paget's, metastasis, etc.....		
4. Osteoporosis		
{ a. Post-menopausal.....		12
{ b. Senile		
c. Secondary to invalidism.....		1
d. Dietary.....		
5. Total aseptic necrosis.....		9
6. Circulatory insufficiency.....		2
7. Fracture line obliquity..... (late)		All
8. Diastasis (late).....		All
Total.....		32

imperfect reduction and the opposite is also true. Failure in more than one factor courts disaster. According to these criteria it is not difficult to determine with some accuracy where the basic defect lies in almost all instances of non-union whenever adequate post-reduction films are available. During the past few years thirty-two cases of non-union were so classified (patients who came to us following initial treatment elsewhere, who were seen in consultation and patients following our own unsuccessful therapy). The results of this classification are exhibited in Table I. The first column in Table I represents an enumeration of the conditions which weaken the primary fixation but do not delay healing. In the middle column are the conditions which weaken the primary fixation and also cause healing delay. In the third column are the conditions which do not cause weakening of the initial fixative strength but which cause healing delay. Reparative tissue in these



FIG. 1. Two types of slipping; A, early, generally reflecting poor insertion; B, common slip due to failure of mid-cervical bone.

conditions can be so slow in developing that it fails to take hold before the initial fixation deteriorates to the point of slipping.

It is important to note the high proportion of failures that presented no clear evidence of aseptic necrosis. If the instances of non-union herewith classified represent a fair cross section of those generally encountered and if our reasoning has been correct about the reciprocal relationship of the fixation factors, a large proportion of non-unions might be avoided by firmer fixation. A firmer bond at the fracture site can overcome the defect in material or workmanship. It might hold firmly enough to tide over until the reinforcement of healing tissue has developed.

#### MECHANISM

The actual mechanism of the fracture slip shows very little variation in these separate categories. If the nail is used, it may buckle out of the head. This mishap in our experience generally occurs in the early postoperative period and reflects inadequate or improper insertion. The

majority of slips later during convalescence occur with the capital fragment securely fastened to the instrument in their original relationship and with this entire unit displaced downward with reference to the distal fragment. (Fig. 1.) Such slips are due to the weak bony structure of the femoral neck of the distal fragment close to the site of the fracture (Ward's triangle) and its inability to buttress the immobilizing device adequately. (Fig. 2.) The poorly trabeculated spongiosa of this area projects the main support of the nail to far below the fracture site and close to its point of insertion in the cortex. The strain upon this remote support is magnified greatly in accordance with the laws of leverage, often approaching precarious limits. The critical point is exceeded when the decalcification of sustained fracture hyperemia is added to any of the aforementioned basic defects. The capital fragment and pin slide backward and downward until a vertical fracture line is produced which virtually precludes further healing.

In the anatomic laboratory this weakness is not difficult to demonstrate. The ease is surprising with which apparently firm fracture fixations with a wide variety of instruments can be broken up by relatively slight force applied to the distal extremity in the direction of external rotation. Once the fixation gives ever so slightly in this plane, solidarity in other planes develops prompt weakness and it becomes easy to push the head into varus position. It is reasonable to assume that the greater part of our clinical failures to maintain alignment originates in such a primary posterior slip.

In the laboratory only one maneuver mitigated against this weak point, firm impaction. By impaction I do not mean merely close contact of the fracture surfaces but actual intrusion of  $\frac{1}{4}$  inch or so of neck into the substance of the head. When such impaction is obtained by proper application of the corkscrew bolt, the force of external rotation may be increased until the round ligament finally ruptures and the head dislocates anteriorly. The integrity of the fracture fixation remains undisturbed. This experiment serves to emphasize that the corkscrew bolt presents no material advantages over other devices in the maintenance of normal opposition of the fracture surfaces. Its function is the production and maintenance of real impaction; and only when this is attained, does the bolt provide a stronger bond than other fixation instruments. When it is properly used to produce impaction, the strength of the fixation is considerably greater than that of any other device tested.

It is my belief that impaction also yields more rapid healing than simple apposition but this rests entirely on clinical evidence and is not amenable to simple laboratory verification.

#### HISTORY

A number of surgeons have interested themselves in compression mechanisms for greater security in hip fractures. To my  
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knowledge Henry<sup>3</sup> was the first to experiment along these lines. His device, described in 1934, did not appear practical for several reasons, chief among them being the inadequate hold on the femoral head. (Fig. 3.) It is my belief that the corkscrew

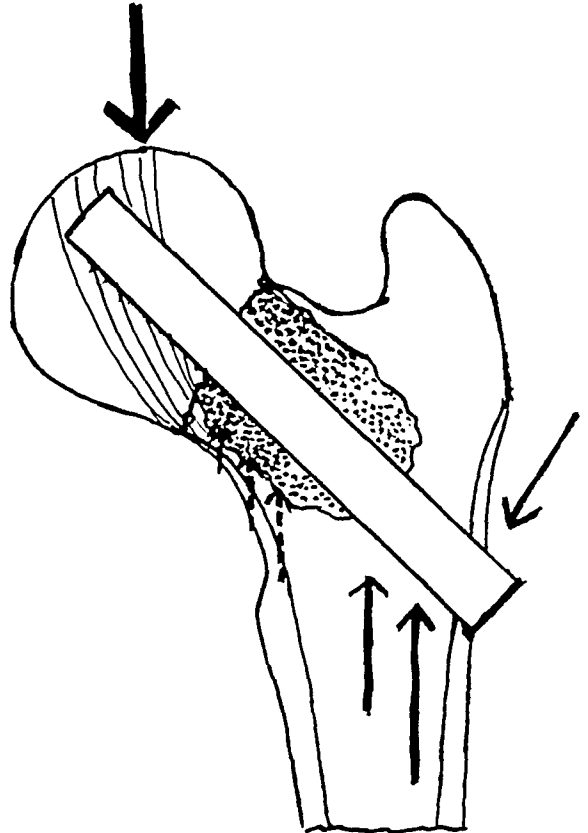


FIG. 2. The distribution of forces with non-compression instruments; illustrating the precarious support of the mid-cervical bone. This is overcome by compression and impaction.

bolt described in 1936<sup>4</sup> was the first practical instrument utilizing the compression principle. (Fig. 3.) Except for the change of metal from steel to Vitallium, it has been used essentially unmodified in our institution since its original description and is the instrument employed in the cases herewith presented.

Various instruments made for a similar purpose have appeared in subsequent literature, the most important of them being those of Henderson,<sup>5</sup> Putti,<sup>6</sup> Godoy-Moriera<sup>7</sup> and Virgin.<sup>8</sup> (Fig. 3.) The efficiency of these instruments varies considerably and it is doubtful whether any

of them represent any noteworthy improvement over the corkscrew bolt. This is because a corkscrew bolt provides the greatest pull for an instrument of its size. A corkscrew has no central core or shank. It is much easier to make an instrument

not encountered in its successors is the simple trochanter catch which locks it securely against rotation after insertion. If revolution of the entire bolt complex should occur after its insertion, even to the extent of half a turn, immediate loss of compres-

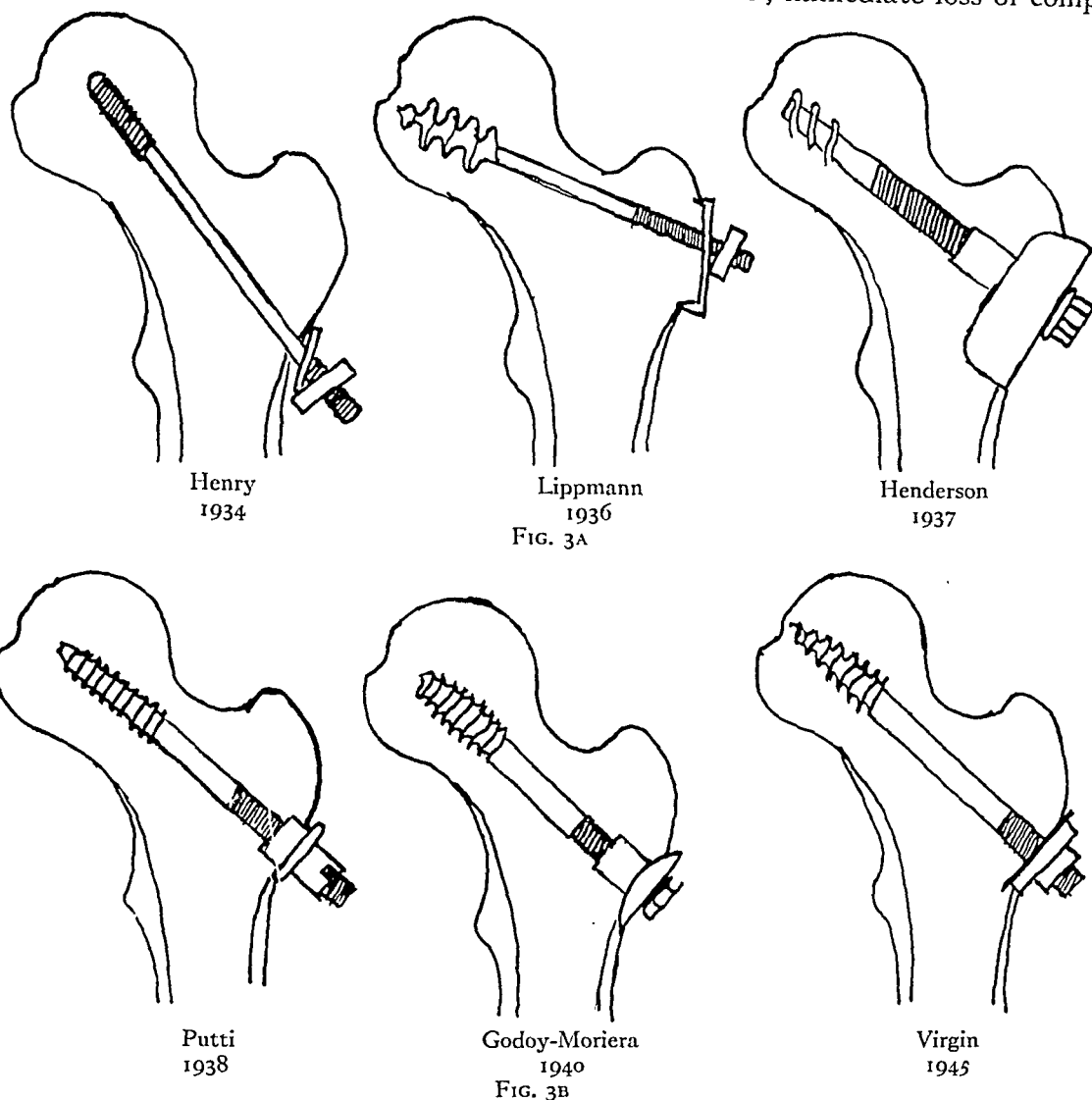


FIG. 3. A and B, various devices used for compression of hip fractures.

with a solid core because it can be turned on the lathe while a corkscrew must be twisted. To supply equal power, moreover, its over-all diameter must be greater than that of the corkscrew. A smaller over-all diameter but equal power means less bone destruction, easier placement and less force tending to rotate the femoral head out of position during insertion.

Another advantage of the corkscrew

sion force and impaction would naturally result. There are a number of less important conveniences of the corkscrew bolt that I have not presented, namely, it cuts its own thread and the excess shaft may be cut off easily, so dispensing with the need of any measurements and assortment of sizes.

The Virgin traction screw is larger but not otherwise dissimilar to the corkscrew

bolt and it should function well. (Fig. 3.) Recently Virgin and MacAusland<sup>8</sup> have added a coiled take-up spring below the nut but I am not certain whether or not this represents an improvement. In the absence of neck absorption it does not

fractures and of providing the same therapeutic approach for all of them. For consistently good results it is necessary to liberate oneself from the dogma of standardized treatment as we have learned to do with other fractures. When the bone is

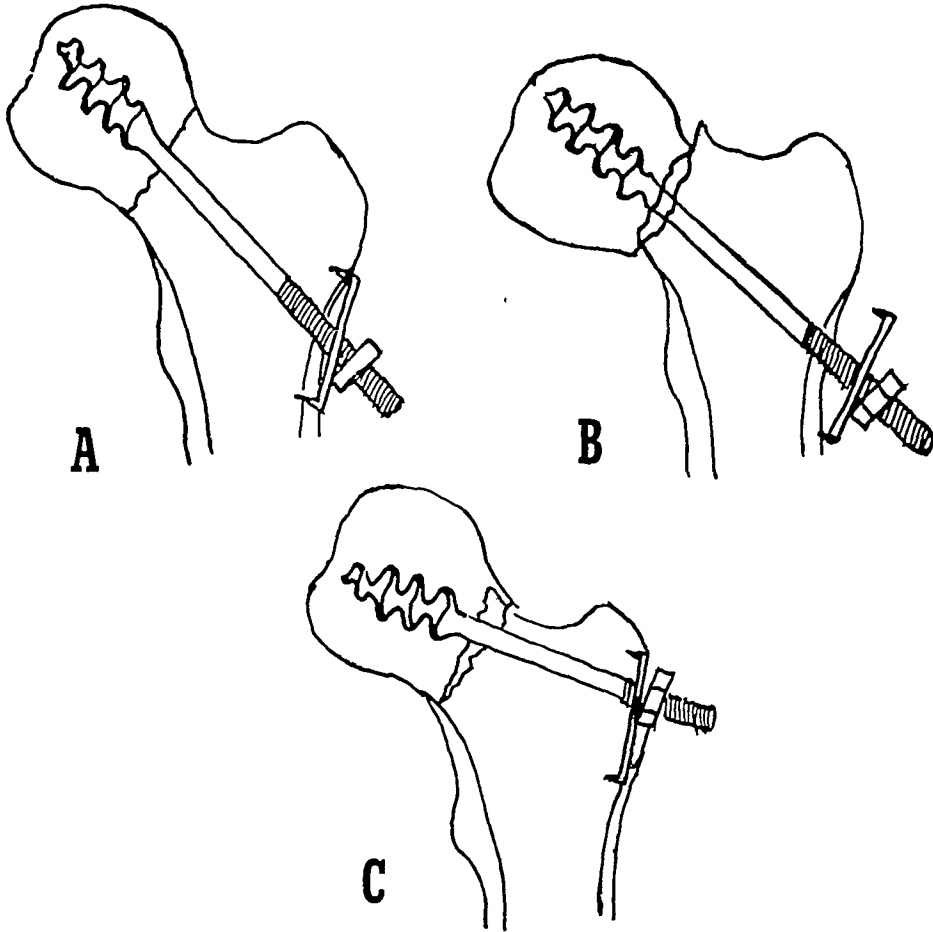


FIG. 4. A, improper low insertion; note angle with fracture line; B, the hazard of low insertion; C, the proper insertion and the valgus compression it produces.

function except as a lock washer. If neck absorption should develop, the expanded elastic spring would appear to provide a very precarious and unstable fixation at best. In our experience neck absorption has proven to be an extremely rare source of difficulty occurring essentially as a sequel to motion at the fracture site and due, in turn, to inadequate primary fixation.

#### APPLICATION

In the foregoing I have tried to indicate the error of pigeon-holing intracapsular  
*July, 1949*

thin, when there are indications that healing will be slow or when reduction or fixation have not materialized as well as planned, firmer fixation may be sufficient to overcome these handicaps. Two or even three bolts can be utilized freely for this purpose. The use of an extra instrument has proved to be such a simple procedure that it is used by us almost routinely. The double bolt method owes its simplicity to the fact that there is no need of penetrating the dead center of the head. An eccentric position is compensated for by merely directing the second bolt into the opposite

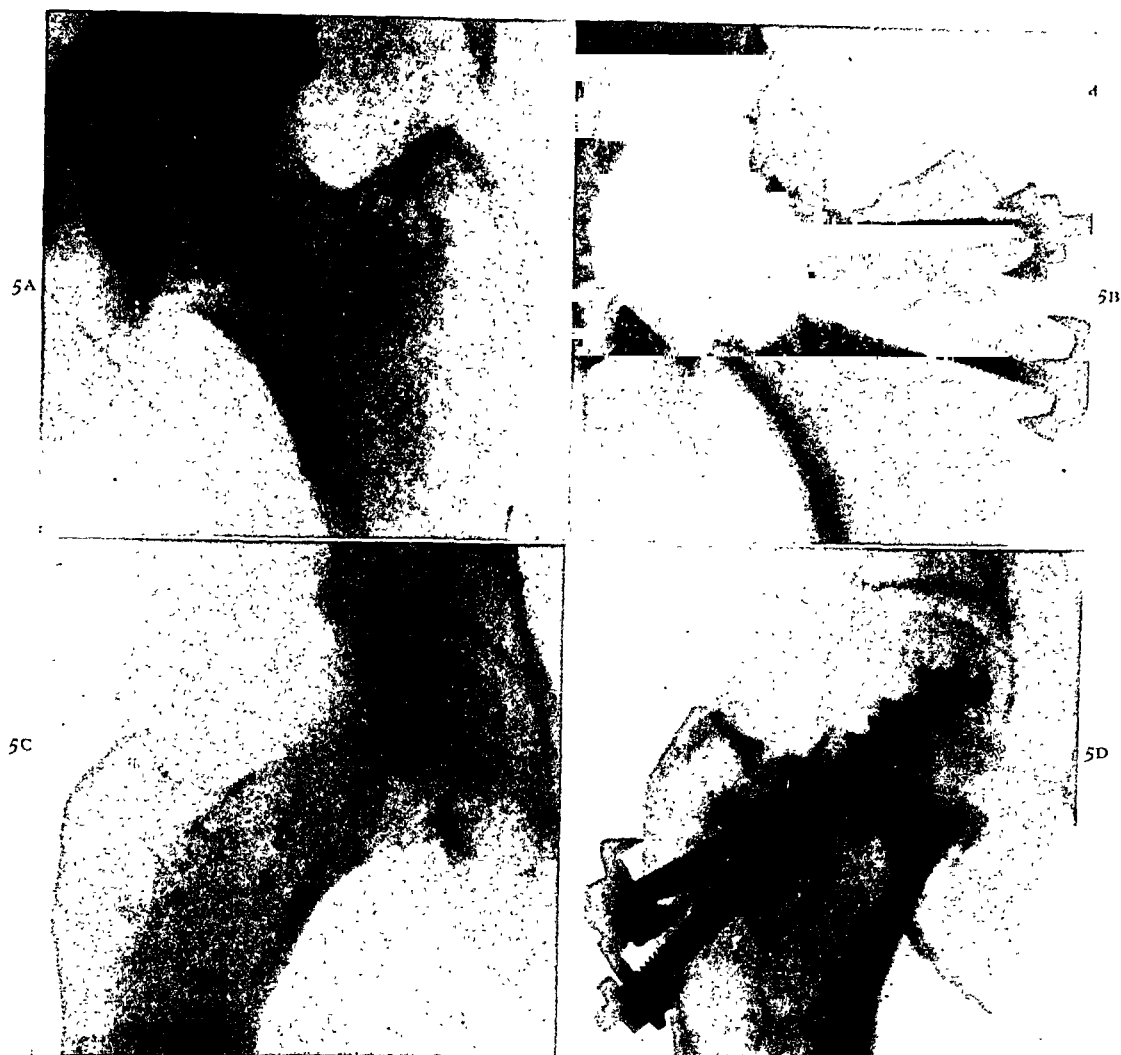


FIG. 5. Two illustrative instances of compression on the operating table. Note the comparable rotation of the shaft in pre- and post-fixation films; A and B, Case I; C and D, Case II.

head quadrant; the proper angulation of this bolt is easily accomplished without the help of any directing mechanism.

Perhaps the most important difference between the application of the corkscrew bolt and other devices is the election of a high insertion point. If two bolts are used, at least one of them must be inserted above the vastus ridge and the other not far below it. (Fig. 4.) From this point the instrument skirts the superior border of the neck to enter the head at approximately its center or just below it. With insertion above the vastus ridge, any tendency for the head to displace during compression will be into valgus and safe position. A lower cortical insertion can

and often has produced satisfactory impaction but it presents the hazard of pulling the head down into varus position, the position of disaster. It seems to be particularly difficult to alter the fixed pattern of low insertion, employed with other fixation devices, to conform to these criteria. In the illustrated material you will note a number of improper insertions by members of our own staff.

The high insertion point has the additional advantage of simplifying aiming because of its greater proximity to the head. This is useful as the bolt has no core and cannot be cannulated to slide over a wire. For those who prefer it, however, the wire technic can be employed and the

corkscrew bolt directed parallel to the wire at any point within a  $\frac{1}{4}$  inch radius.

The compression maneuver is always initiated in the bolt with the highest point of insertion and  $\frac{1}{4}$  inch of impaction demands five or six complete turns of the nut. To avoid buckling, it is best to apply these turns one or two at a time, alternating them with the second bolt while an assistant firmly holds the leg in the position of full internal rotation. Perhaps the best evidence that these maneuvers effectively produce true impaction is available in the comparison of pre- and post-compression films taken on the operating table. (Fig. 5.)

#### POSTOPERATIVE CARE

After operation the question of when to begin weight-bearing must be decided upon in regard to the attributes of the individual patient and his hip fixation. Because of the strong grip of the corkscrew bolt, it was considered justifiable to experiment with early weight-bearing, permitting full weight-bearing in six to eight weeks in favorable cases. All but three of our patients followed this plan. Ill effects were not noted except on two patients, both of whom later proved to have complete necrosis of the capital fragment. Whether the solidity of these fixations is due to the efficiency of the corkscrew bolt or to the speedy repair which compression develops is difficult to determine. Probably both factors are operative. The two instances of slipping that occurred in the presence of totally necrotic heads are not disturbing. These fractures probably would have slipped at a later date, even without weight-bearing, and solid union, even if attained, would have gained little. It might be that the early recognition of these cases that slipping provides will prove advantageous rather than harmful.

There is little to support the contention of some that those hips predisposed to later collapse are unfavorably influenced by early weight-bearing. The fragility of the dead head does not appear until a good many months later when, as Phemister<sup>9</sup>

has shown, the ingrowth of vascular granulation tissue reaches sizable proportions. It must be emphasized, in any event, that until our present series increases sizably, early weight-bearing must remain a purely experimental procedure.

TABLE II

Intracapsular Fractures	No. Cases
Died within 8 weeks.....	3
Protracted unrelated illness; could not be followed	3
Too recent for final evaluation.....	4
Followed 1-4 years.....	21
(average 1 yr. 11 mo.)	—
Total.....	31

TABLE III

TWENTY-ONE CASES FOLLOWED ONE TO FOUR YEARS

	No. Cases	Per Cent
Average age 68.3 years		
Average follow-up—1 yr. 11 mo.		
Non-union due to total aseptic necrosis.	2	9.5
Late collapse of head due to apical necrosis.....	2	9.5
Arthritis of mechanical origin.....	1	4.8
Rehabilitation locally complete.....	16	76.2
Total.....	21	100.0

It is regrettable that the small orthopedic service of a general hospital does not yield sufficient material to justify accurate statistical analysis. My reluctance to submit a statistical study based on so few cases has yielded only for the purpose of illustrating how well the corkscrew bolt appears to be producing the benefits theoretically anticipated.

Since the institution of our present approach four years ago there have been thirty-one intracapsular unimpacted fractures of the hip subjected to internal fixation with the Vitallium corkscrew bolt. (Table II.) Three of the patients died before the expiration of eight weeks and so permitted no evaluation. Three other deaths occurred within eighteen months following operation after protracted illnesses not associated with the injury or its repair. Since these patients were invalided at remote points and were not available for





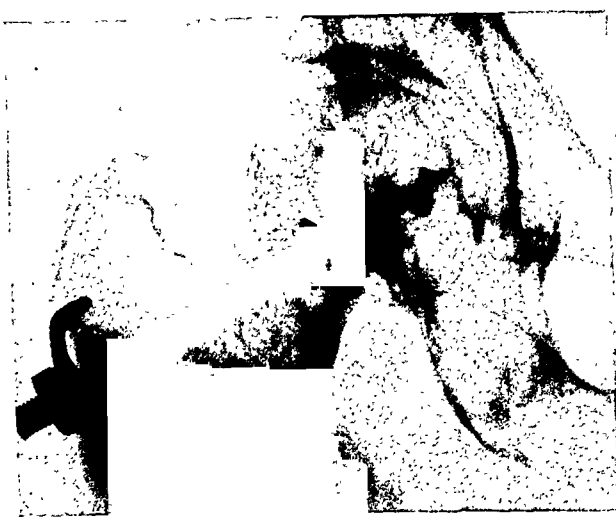
FIG. 6. Complete abeyance of arthritic changes or manifestations; A, two years; B, two and a half years; C, three years; D, one year.

control observation, they were omitted from the present report. Four patients sustained their fractures and were operated upon too recently for final evaluation. Two of these have healed and the other two appear to be healing satisfactorily. The remaining twenty-one patients have been observed for one to four years, the average duration being one year and eleven months. Of these twenty-one patients nineteen have healed with solid bony union (90.5 per cent). (Table III.) In the two patients whose fractures failed to heal proven total aseptic necrosis of the capital fragment developed; this was interpreted as the cause of failure in these instances. In the nineteen patients whose fractures

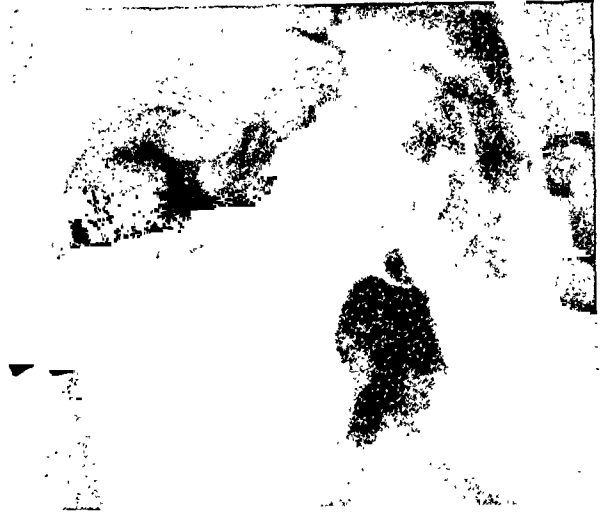
healed, collapse of the head eight and ten months after fixation occurred in two, an incidence of 19 per cent of total and partial aseptic necrosis. After about the same length of time in another patient mild arthritis of the hip developed due to a screw bolt which was permitted to penetrate for this time into the joint cavity. In the sixteen remaining cases, of which Figure 6 is illustrative, there has been complete abeyance of arthritic changes or manifestations. It is recognized, of course, that such symptoms might still develop. At the present time it would seem that from the fracture standpoint these patients have been completely rehabilitated (76.2 per cent). Inasmuch as failure to heal was



7A



7B



7C

FIG. 7. A, preoperative film of a fracture slip three months after initial treatment with Moore pins; B, postoperative view with the corkscrew bolt; C, illustration of fracture site one year later.

seen only in the presence of total capital necrosis, it would appear that this rate of healing represents the maximum potential for those patients treated. As for aseptic necrosis of both varieties, the total percentage of 19 per cent is not significantly out of accord with figures obtained in other hands.

Aside from the overt arthritic changes encountered in the collapsed head instances and in the case with the protruding screw, the absence of arthritis in the remaining patients was surprising. One cannot help but wonder whether it might bear some relationship to the technic of the application of the instrument which is entirely torsional and which includes no hammering on soft bone. A process in the nature of

Kümmell's disease has never been satisfactorily excluded from suspicion. In no instance was significant neck absorption or diastasis observed except after slipping had occurred in the two cases of non-union due to dead heads. With three exceptions, all of the patients in this series began full weight-bearing six to eight weeks after operation and no ill effects were noted. It may be of some interest to illustrate a few additional examples of the use of the corkscrew bolt under particularly adverse conditions.

Figure 7 represents a fractured hip of a patient who came to us almost three months after initial treatment with Moore pins elsewhere. She had not borne weight but pain of progressive severity had

caused complete invalidism. The corkscrew bolt permitted full weight-bearing six weeks after removal of the pins and secondary fixation. Firm union developed promptly. Six other late screw bolt fixations were performed in this fashion with one failure. Late insertions have been undertaken only when the head is neither dead nor so atrophied that it cannot furnish adequate support for the fixative instrument.

#### SUMMARY AND CONCLUSIONS

Despite the many advances in the therapy of intracapsular fractures, non-union continues common even in the presence of complete viability of the capital fragment. Thirty-two instances of non-union, representing the failures of many surgeons including our own, were analyzed with reference to the basic cause of mechanical failure in each of them. This material indicated that the reserve strength of routine fixative devices is small and suggested that it might be possible to avoid non-union in a large proportion of such cases if stronger fixation were available.

The mechanism of slipping after routine fixation was analyzed and, by cadaver experiments, it was possible to demonstrate that the corkscrew bolt properly applied provides additional strength to the fixation. Proper application of the corkscrew bolt entails the production and maintenance by the device of a firm impaction of  $\frac{1}{4}$  inch, without which the instrument holds no more securely than other routine devices.

In the insertion of the corkscrew bolt, the importance of high insertion is emphasized. Insertion more than  $\frac{1}{2}$  inch below the vastus ridge entails the risk of pulling the capital fragment down rather than into

valgus and favorable position. Since the objective is to secure maximum strength and since the porosity of the bone is very variable, it is wise to employ two corkscrew bolts instead of one, thus providing an extra margin of safety.

In the patients treated according to this plan, failures to heal have occurred only in the presence of total necrosis of the capital fragment. Since the incidence of total necrosis was low, the healing rate attained would appear to represent the maximum potential of the patients treated. The low incidence of arthritic changes in these cases appears to be in marked contrast to its frequency in other studies in which nails were used. The insertion method, torsion rather than hammering, might play a role in the avoidance of this complication. Several examples of the use of the corkscrew bolt under particularly adverse conditions are also included.

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# BRACHIAL PLEXUS BLOCK ANESTHESIA

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THE purpose of this paper is to re-emphasize the value and usefulness of brachial plexus block anesthesia for surgery of the upper extremity and to present our clinical observations and impressions based on 1,100 consecutive brachial plexus blocks. Clinical findings in the comparison of 2 per cent procaine, 1.5 per cent metycaine and 6.15 per cent pontocaine as anesthetic agents for use in this type of regional anesthesia are also presented.

We were prompted to write this paper by several factors. The first is that a perusal of American literature reveals an insufficient number of articles written about this form of anesthesia. This, of course, is directly related to the fact that this form of anesthesia is not as popular nor is it used as often as it should be. Both of these conditions are present because certain misconceptions exist among some surgeons and anesthesiologists that this form of anesthesia is difficult and time consuming and that the percentage of failures is too high to warrant its use. Also that the advent of pentothal sodium has given some the impression that it is the simplest and safest agent to use in all cases including upper extremity surgery, and there is no need to "fuss about blocks." It is hoped that the presentation of our findings, with a complete review of American literature will correct these misconceptions, and encourage more anesthetists and surgeons to employ this adequate form of regional anesthesia.

Brachial plexus block, like all other regional anesthetic procedures, if successful, offers certain advantages to the patient, surgeon and anesthetist which may not be had with general anesthesia.

The physical economy of the patient is

taxed the least with this type of anesthesia. Only a limited area (upper extremity) is anesthetized without disturbing the metabolism of the rest of the body. This consideration is of great importance in the poor risk patient who cannot tolerate the stress imposed by general anesthesia. Patients who present complicating conditions such as heart, renal and pulmonary diseases, chest injuries, diabetes, etc., are able to withstand surgery done with brachial block anesthesia without aggravation of the disease. It may be assumed, therefore, that nerve block is the anesthetic of choice in this type patient.

This, however, does not infer that it is to be used only in poor risk patients. On the contrary, all patients who present themselves for surgery of the upper extremity should be afforded the benefits of this form of regional anesthesia, for in addition to the above, it has the following advantages: (1) This anesthesia affects a physiologic sectioning of the nerves supplying the upper extremity with a consequent block of painful impulses which may be caused by trauma. Although Atkins<sup>1</sup> has attempted to show that the block will not help but rather aggravate shock, it is our impression, based on clinical experience, that patients who come to surgery in actual or impending shock improve as soon as the pain has been relieved by the block. Of course, the fluids that have been lost must be replaced. (2) Any patient who arrives at surgery with a full stomach presents no difficulties, and no danger of aspiration exists if he vomits. (3) If properly performed, it gives a minimum degree of discomfort to the patient and it allows patients who dread losing consciousness to be awake. (4) Patients with brachial blocks may be ambulatory. Out patients

may be sent home after a closed reduction of a fracture or repair of a laceration. It is also of great benefit in aged patients in whom early ambulation is necessary to prevent complications. (5) Whenever fluoroscopy or x-ray is a necessary adjunct to the surgical procedure, brachial plexus block eliminates the dangers of explosions, respiratory depression or obstruction in the darkened room, and the patient is able to cooperate with the surgeon. (6) Post-anesthetic nausea, vomiting and other complications such as atelectasis, shock, distention and dehydration are absent. This allows the patient to eat a regular diet and thus benefit from oral feeding. Long drawn out operations on the upper extremity such as repair of tendons and plastic procedures, if done with general anesthesia, require a comparatively large dose of drugs. These cases are sometimes followed with postoperative depression and complications which are entirely out of proportion to the operation.

The benefits derived by the surgeon are also numerous. He has perfect operating conditions. By varying the strength of the anesthetic solutions, motor power may or may not be abolished. A higher strength solution will cause muscular relaxation not attained with general anesthesia unless large doses of the latter are given or curare is used. Such relaxation is necessary in reduction of fractures and dislocations and other orthopedic procedures. If it is necessary that the patient retain some motor power in order to help the surgeon identify tendons, a weaker solution may be used. In the absence of the anesthesiologist a surgeon who is experienced in the technic may block the patient and then perform the operation. This is of great advantage in rural practices where a specialist in anesthesia is not always available.

It is advantageous for the anesthesiologist to use this type of anesthesia for it is relatively easy to learn and execute, and with a little experience it is successful in a high percentage of cases. It is cheap to administer and the equipment necessary is

not bulky and can be transported easily. In unusual circumstances, when economical use of surgeons, anesthetists, and nurses is important, regional anesthesia is of great value. On many occasions during the war some of us were forced to run several operating rooms with only technicians assisting. In such instances regional anesthesia was the safest and best method. We could perform several blocks and have the technicians watch the patient. In this manner one anesthetist was able to supervise two or more operating rooms. This, of course, is not the ideal situation and should not be done unless it is absolutely necessary.

The ward nurses appreciate the use of regional anesthesia. Patients who return to the wards awake, without nausea and vomiting, and are able to help themselves immediately, relieve the nursing staff of a load which makes possible the surgical care of many more patients at one time.

The disadvantages of brachial plexus block are few. As with any other form of regional anesthesia, the anesthetist must fulfill certain prerequisites in order to obtain good results. These prerequisites are (1) a thorough knowledge of the anatomy, (2) patience and gentleness in performing the block and (3) the waiting of sufficient time (from fifteen to forty-five minutes) after the block is done before surgery is started. These are disadvantages only if the anesthetist does not observe (1) and (2) and plan for (3).

#### REVIEW OF AMERICAN LITERATURE

It is of interest to note that Halsted<sup>2</sup> was the first to realize brachial plexus block anesthesia, when in 1884 "under direct exposure he blocked the roots in the neck with cocaine solution." Crile<sup>3</sup> also used this method in 1897 for the disarticulation of a shoulder. In 1911 both Hirschel<sup>25</sup> and Kulenkampff<sup>26</sup> of Germany independently reported the first blind injection of the plexus through the skin, without direct exposure. These reports were followed by many others in Europe but only compara-

tively few have appeared in American literature. Although we are certain that many American doctors have employed this form of anesthesia, it is rather impressive that only a little over 1,000 cases have been reported (excluding the 1,000

quate mental picture of its anatomy are essential prerequisites for successful anesthetization of the plexus, and that the following points merit mention: (1) After emerging from between the scaleni muscles, the plexus is located rather superficially in

TABLE I  
REVIEW OF THE AMERICAN LITERATURE

Note

Date	Authors	No. B.P.B.	Anesthesia Obtained			Complications
			Perfect	Partial	Fail	
1884	Halsted (quoted by Matas) <sup>2</sup>	N.R.	Obtained good results			None reported
1897	Crile <sup>3</sup>	N.R.	Obtained good results			None reported
1914	Strauchbauer <sup>4</sup>	8	8	0	0	None reported
1914	Neuhoff <sup>5</sup>	N.R.	Obtained good results			Musculospiral paresis
1915	Simpson <sup>6</sup>	N.R.	Obtained good results			None reported
1927	Livingston and Wertheim <sup>7</sup>	105	82	20	3	Transient, mild toxic reactions
1927	Labat <sup>8</sup>	N.R.	Obtained good results			None reported
1927-8	Hanrahan <sup>9</sup>	47	31	11	5	One procaine reaction
1928*	Kulenkampff and Persky <sup>10</sup>	1000	Obtained good results			Procaine reaction; plexus irritation
1928	Hay <sup>11</sup>	N.R.	Obtained good results			Vasomotor reaction; pneumothorax
1929	Strode <sup>12</sup>	4	4	0	0	None reported
1935	Rhone <sup>13</sup>	33	27	2	3	None reported
1936	Touhy <sup>14</sup>	N.R.	Obtained good results			None reported
1937	Tarsy and Steinbrocker <sup>15</sup>	81	Obtained good results			None reported
1939	Halperin <sup>16</sup>	28	25	3	0	None reported
1939	Miltner and Chao <sup>17</sup>	233	187	24	22	None reported
1939	Arnold and Gibson <sup>18</sup>	N.R.	Obtained good results			None reported
1943	Griswold and Woodson <sup>19</sup>	100	97	0	3	Two mild proc. react.; pneumothorax—2 cases
1944	Murphy <sup>20</sup>	45	42	0	3	None reported
1944	Phillips <sup>21</sup>	160	147	7	6	Pneumothorax* 3 cases
1944	Greene <sup>22</sup>	150	133	7	10	Pneumothorax; procaine reaction
1946	Ansbro <sup>23</sup>	27	27	0	0	Slight toxic reaction
1946	Damarjian <sup>24</sup>	100	100	0	0	Transient pneumothorax; persistent paresthesis

N.R. = Not Reported

\* These are German cases reported by Kulenkampff

German cases reported by Kulenkampff in his American article). (Table I.)

#### ANATOMY

The anatomy of the brachial plexus and its ramifications to the upper extremity are too well known to warrant any discussion. The following diagram is included only for completeness. (Fig. 1.)

However, we would like to re-emphasize that a thorough knowledge and an ade-

quate mental picture of its anatomy are essential prerequisites for successful anesthetization of the plexus, and that the following points merit mention: (1) After emerging from between the scaleni muscles, the plexus is located rather superficially in the posterior triangle of the neck, being covered by the superficial fascia, platysma and deep fascia. (2) The three trunks converge toward the upper surface of the first rib and then pass into the axilla through its apex underneath the mid-portion of the clavicle. (3) Over the rib where the three trunks are grouped closely together, the subclavian artery lies immediately anterior and medial to the plexus. This vessel is also superficial and thus

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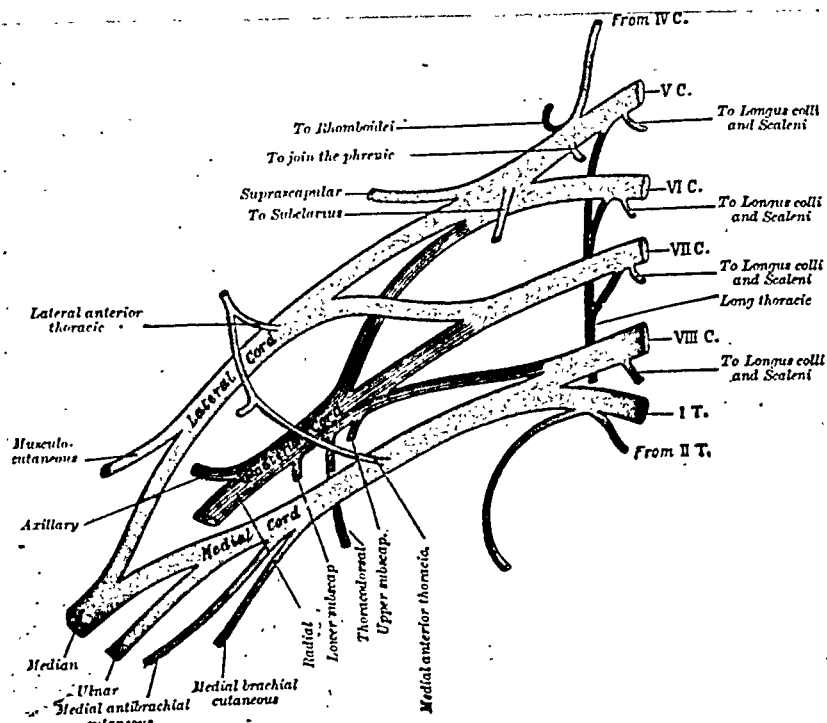


FIG. 1. The brachial plexus.

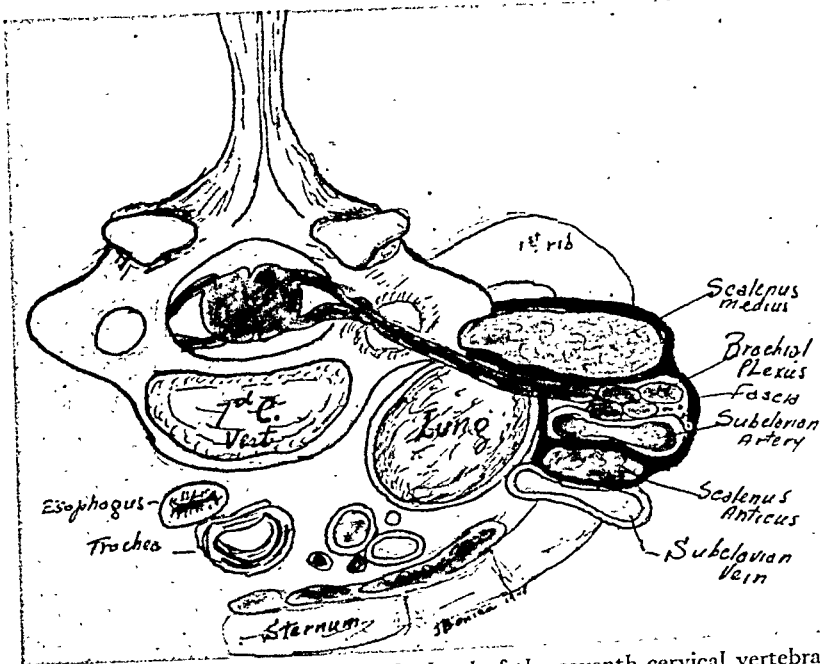


FIG. 2. Schematic cross section at the level of the seventh cervical vertebra showing the fascial compartment containing the brachial plexus and subclavian artery.

affords a palpable landmark to the plexus.

(4) The fascial compartment made up of the fascia extending from the anterior and middle scaleni muscles ensheaths the plexus and artery, making possible the deposition and retention of anesthetic solutions within a relatively closed space, and thus affords the best means of anesthetizing the plexus. (Fig. 2.) (5) The first rib is an immediate deep relation which can be easily located by the needle. It acts as our most important landmark and if used properly, serves as a screen to prevent entrance of the needle into the pleura and lungs.

#### ANESTHETIC PROCEDURE

*Preliminary Considerations.* During the routine preoperative visit the anesthesia should be discussed in detail with the patient and its advantages pointed out.

Proper pre-anesthetic sedation is an absolute necessity, particularly in apprehensive patients. Many regional procedures have been called failures because the unmedicated, apprehensive patient interpreted touch as pain and without further evaluation was immediately narcotized. We are certain that this is one of the most important factors in obtaining good results with blocks. This is particularly true in children who can be operated upon with regional procedures if indicated, provided they are sedated properly. A proper dose of the barbiturate-morphine-scopolamine combination should be given.

Whenever possible, the block should be started at least forty-five minutes before the scheduled time of operation, so that the anesthetist has sufficient time to perform the block without haste and still have at least thirty minutes between the time he finishes the block and the start of the surgical operation.

The procedure should be described to the patients, emphasizing the necessity of their cooperation for a successful block. They are instructed to snap out the word "now" when paresthesia is felt (described to them as a feeling of electricity running down to the hand or fingers).

The patient lies in the supine position with a small pillow under the upper thoracic spine allowing the neck to hyperextend and the shoulders to fall back. The head is rotated to the opposite side and the shoulders depressed caudad.

The identification of all the landmarks is done preliminary to the preparation of the skin. The subclavian artery, which is considered the most reliable landmark, is identified by palpation and the mid-point of the clavicle is also identified and marked.

*Technic.* Our technic of choice for brachial plexus block has been a modification of the supraclavicular approach. With aseptic conditions prevailing, a skin wheal is made 1 cm. above the clavicle just posterolateral to the subclavian artery. This usually corresponds to the mid-point of the clavicle; and in patients in whom the artery cannot be palpated, this mid-point is utilized as a landmark. The proper length needle is selected (5 cm. 22-gauge short beveled) and inserted through the wheal directing it caudad, mesiad and dorsad toward the spinous process of the third thoracic vertebra. At this point it should be emphasized that caution and gentleness on the part of the anesthetist are essential for successful results in brachial block anesthesia. Indiscriminate or careless and fast insertion of the needle may cause damage to nerves or puncture of the pleura before the operator is able to realize it. If a short beveled needle is used and is introduced slowly and gently, the operator is able to discern penetration of the deep fascia 0.5 to 1 cm. deep, denoting that the needle is within the fascial compartment which encloses the plexus. Proceeding slowly, the needle is inserted until paresthesia is obtained or until the recorder, which is placed 3 cm. from the needle point, is against the skin. If the direction of the needle is right and the patient is not fat, this is deep enough to contact the upper surface of the first rib just posterolateral to the artery. In fat individuals with a high clavicle it may be necessary to go 4 or even 5 cm. deep before the rib is touched.



Absence of paresthesia or contact with the rib at these depths denotes that not only the plexus but also the rib has been missed, with danger of piercing the pleura if the needle is introduced deeper. If the rib is contacted without paresthesia or pulsation of the needle, it has passed between the trunks of the plexus without contacting them or, more likely, the needle has been placed too far posterolaterally in an effort to avoid the artery. If paresthesia is not obtained, the needle should be withdrawn, the landmarks again checked and the needle reinserted. We feel very strongly that paresthesia should be obtained because it denotes contact with the plexus assuring us of a successful block with a quicker onset. We do not agree with some authors that it is dangerous because of possible damage to the nerve trunks, and have not observed any signs of injury following these blocks which could be attributed to this. On the other hand, we do not approve of promiscuous probing and, if after five or six careful insertions paresthesia is not obtained, one of the other technics should be used.

When the plexus is engaged, the patient senses paresthesia and, as previously instructed, snaps out the signal whereupon the needle is immobilized, aspiration is performed several times and, if no blood appears, 15 cc. of the solution is injected. During the injection the patient senses vague paresthesia due to the pressure exerted by the solution as it is being injected. This denotes the close proximity of the needle point to the plexus. After the solution has been injected the syringe is detached and the needle inserted a little farther in until its point contacts the rib. If during this procedure the patient informs the operator of *different* paresthesia, the needle is again arrested and 10 cc. more is injected. Otherwise the rib is contacted, the full syringe is again adapted and the 10 cc. of solution is injected as the needle is progressively withdrawn, depositing the last cc. of solution as the needle point emerges through the deep fascia. The

needle is then reinserted through the same site and directed so that it will strike the rib surface 1 cm. nearer its sternal end. This will place it immediately posterolaterally to and in contact with the artery, a fact which is evidenced by the synchronous oscillations of the needle with the pulsation of the artery. Upon contacting the rib the syringe is adapted and 7 to 10 cc. of solution is injected as the needle is withdrawn. The third insertion through the same site is made, this time directing the needle so that it will strike the rib surface 1 cm. posterolateral to the first injection and the maneuver is repeated. If during the second or third injection different paresthesia is obtained, the needle is arrested and 5 cc. of solution is deposited. It is important to perform the aspiration test every time the needle point is moved. During injection number two the artery is sometimes pierced which is of no clinical import provided the needle is moved immediately and hematoma does not occur. By this technic the block is usually completed with 40 to 45 cc. of solution. If the tourniquet is to be used or surgery involves the arm, a subcutaneous ring is made around the upper arm in order to block the branches of the superficial cervical plexus and those of the intercostobrachial nerve. (Fig. 3.)

In the small percentage of patients in whom paresthesia is not obtained, we have used the three-needle technic suggested by Knight and described by Lundy,<sup>27</sup> and also have used a technic described by Patrick<sup>28</sup> and so well illustrated by MacIntosh and Mushin<sup>29</sup> in their monograph. Both of these technics aim at producing a wall of anesthesia between the skin and the rib in the area where the plexus is located. (Figs. 4 and 5.)

Many of the surgical cases have been long drawn out procedures, and in the first one hundred cases the block which was performed with 2 per cent procaine often disappeared before the surgical operation was finished. In those instances the block was repeated, but in some cases this was technically impossible because of the drap-

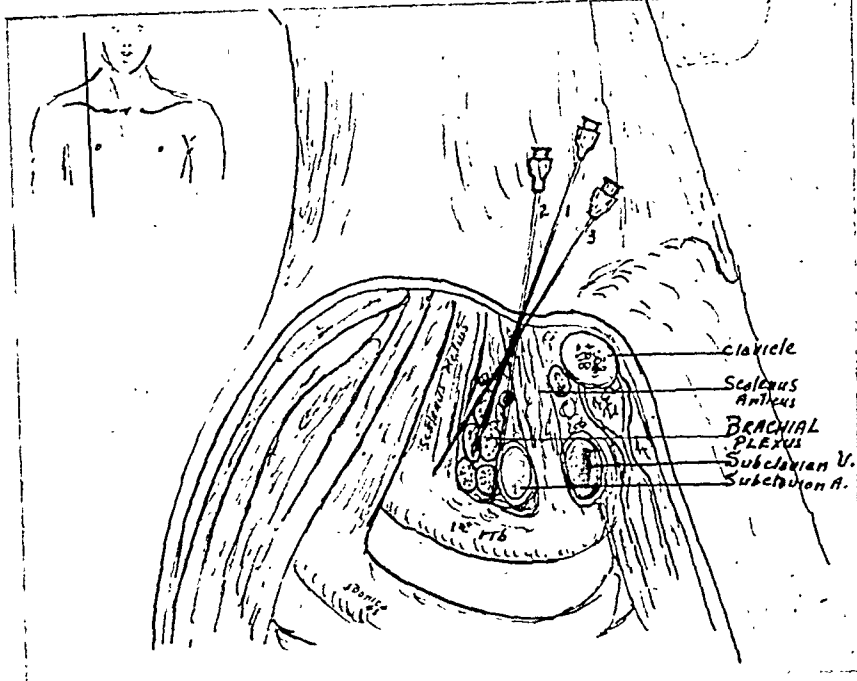


FIG. 3. Sagittal section showing a technic of blocking the brachial plexus.

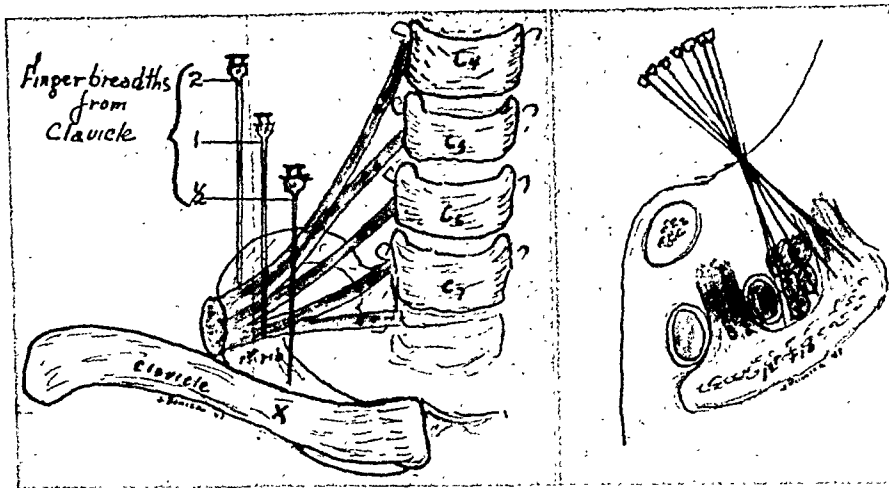


FIG. 4. Knight's three-needle technic of brachial plexus block (after Lundy).

FIG. 5. Patrick's technic of brachial plexus block.

ing or the position of the arm; consequently, we had to give the patient a general anesthesia. Confronted with this problem often enough to be annoying, we thought of a possible technic for its solution. The frequent use of the continuous spinal technic suggested the use of a similar procedure for brachial block, and on August 13, 1945, the one-hundred-first case of this series was anesthetized in almost the same manner as later described by Ansbro.<sup>30</sup> Some months later a continuous brachial block using a catheter in

almost the same manner as used by Irving<sup>31</sup> for continuous caudal was then tried. In addition to the technical difficulties encountered, the results obtained were not uniform in the few cases tried with the latter method; therefore, we abandoned it, resuming the use of the malleable needle technic whenever prolonged anesthesia was needed. Since the introduction of pontocaine, however, the need for continuous brachial block has disappeared, except in rare instances whenever 1 per cent procaine must be used.

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The axillary, infraclavicular and paravertebral routes were also employed in a few cases, either because the supraclavicular route was contraindicated or because we wanted to try the technic. These were found more difficult and not as satisfactory as the supraclavicular approach.

REPORT OF CASES

This paper is an analysis of 1,100 consecutive brachial plexus blocks, most of which were performed in several military orthopedic centers where we were afforded the opportunity of employing regional anesthesia for over 70 per cent of cases. All of the surgery of the upper extremity was performed with brachial plexus block anesthesia, including reduction of dislocation of the shoulder, elbow and wrist joints, reduction of all types of fractures, bone grafts, resection of bones, suturing of tendons and nerves, excision of ganglia and scars. These patients presented both acute traumatic and chronic reconstructive surgical problems involving bones, nerves, muscles and skin. A small number of the blocks were used as a therapeutic measure in arthritis of the shoulder joint, vasospastic conditions and phantom pain. A small percentage of the cases have been performed in two civilian hospitals. Consequently, both military and civilian patients have been included ranging in age from two and a half years to ninety-four years although most of them have been in the eighteen to forty year age group.

The blocks were performed by the permanent and transient members of the staff. The latter group consisted of medical officers who were assigned to one of the centers for a short course in anesthesiology given by the author. Most of these doctors had never done brachial plexus blocks before. We thus were able to evaluate the problems encountered by the novice and experienced operator in the performance of this and other regional anesthetic procedures. (Tables II and III.)

*Additional Anesthesia.* A number of the patients received additional complemen-

tary or supplementary anesthesia because it is believed that if for any reason patients have discomfort, it should be obviated. We emphatically condemn the performance of surgical operations with only partial anesthesia, requesting patients to withstand

TABLE II  
NUMBER OF BLOCKS PERFORMED BY EACH ADMINISTRATOR

Administrators	No. Cases	Perfect Anesthesia		Partial Failure		Total Failure	
		Number	Per Cent	Number	Per Cent	Number	Per Cent
J. J. B.	279	261	93.5	11	4.0	7	2.5
D. C. M.	315	292	92.7	15	4.8	8	2.5
M. O.	104	93	89.4	6	5.8	5	4.8
E. A.	100	92	92.0	4	4.0	4	4.0
H. B.	47	42	89.4	1	2.1	4	8.5
C. G.	47	44	93.6	2	4.3	1	2.1
R. S.	43	40	93.0	1	2.3	2	4.7
E. M.	39	37	94.8	1	2.6	1	2.6
R. C.	14	11	78.6	1	7.1	2	14.3
P. B. J.	21	17	81.0	4	19.0	0	0.0
J. S.	12	12	100.0	0	0.0	0	0.0
W. G.	10	8	80.0	1	10.0	1	10.0
W. B.	12	11	91.7	1	8.3	0	0.0
C. H.	9	9	100.0	0	0.0	0	0.0
C. E. H.	8	8	100.0	0	0.0	0	0.0
W. H.	5	3	60.0	0	0.0	2	40.0
Others 18	35	31	88.6	3	8.6	1	2.8
Total 34	1100	1011	91.9	51	4.6	38	3.5

Note that several students obtained perfect anesthesia in all the patients they blocked.

any discomfort or pain because "it is only going to take a few more minutes."

For reasons of clarity, additional anesthesia has been designated as complementary or supplementary depending upon the effectiveness of the brachial block. Whenever the block has been perfect and for some reason additional anesthesia had to be given, this was classed as complementary anesthesia. Supplementary anesthesia has been defined as that given as a substitute in cases of partial or complete failure of the block.

Additional complementary anesthesia as shown in Table IV has been given to patients who have had a block with a slow onset or insufficient time for onset of anesthesia. Most of the cases were planned so that at least thirty minutes elapsed between the time the block was completed and the start of surgery; but in a number of cases the time was missed, and rather

than make the surgeon wait the patient was given a short acting anesthetic such as pentothal or nitrous oxide-oxygen. This would be administered until the necessary time for the block to be effective and then the patient was allowed to react. If, after

thetic administered. In some patients a brachial plexus block was combined with a spinal anesthetic for bone graft operations; with superficial cervical plexus block for operations in the region of the shoulder joint; with a bracelet for surgery of the

TABLE III  
TECHNICS USED

Technic	No. Cases	Brachial Plexus Block		Complete Anesthesia		Partial Failure		Complete Failure	
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
I. Supraclavicular									
(a) 1 needle with paresthesia									
1. one block.....	871	871	79.2	800	92.0	39	4.4	32	3.6
2. block repeated once.....	44	88	8.0	86	97.7	0	0.00	2	2.3
3. block repeated twice.....	3	9	0.81	8	89.0	1	11.0	1	0.00
(b) Patrick.....	39	39	3.54	38	97.5	1	2.5	0	0.00
(c) Three needles.....	12	12	1.09	9	75.0	2	16.7	1	8.3
(d) Continuous brachial plexus block.....	70	70	6.36	61	87.0	7	10.0	2	3.0
(e) Bilateral brachial plexus block.....	2	4	0.36	4	100.0	0	0.00	0	0.00
II. Infraclavicular.....	3	3	0.28	2	66.0	1	33.3	0	0.00
III. Axillary.....	2	2	0.18	1	50.0	0	0.00	1	50.0
IV. Paravertebral.....	2	2	0.18	2	100.0	0	0.00	0	0.00
Total.....	1048	1100	100.0	1011	91.81	51	4.64	38	3.45

forty-five minutes the patient still had pain, they would be carried with general anesthesia for the rest of the operation and the block was classified as a failure. If, on the other hand, the patient showed no signs of pain and did not complain for the rest of the operation or for a reasonable length of time, this was considered a perfect block. In this way we have demonstrated the fact that many blocks which would have been classed as failures were completely effective. Whenever patients were apprehensive, a minimal hypnotic dose of a general anesthetic was given. On occasion, apprehensive patients who complained of pain or discomfort were given 100 mg. of pentothal or 10 mg. of morphine and they would sleep for the entire procedure. Some patients who had reactions to the drug were given pentothal plus oxygen. Whenever the block would disappear before the end of surgery, it was either repeated or a general anes-

upper third of the arm; and with upper thoracic paravertebral block for operations around the scapula with excellent results.

TABLE IV  
ADDITIONAL COMPLEMENTARY ANESTHESIA

Agent or Technic	No. Cases	Reason
1. Pentothal.....	14	Slow onset of brachial plexus block
2. Pentothal.....	38	For apprehension
3. Pentothal—N <sub>2</sub> O.....	39	Block disappeared before end of operation
4. Pentothal.....	14	Procaine reactions
5. Morphine.....	48	For apprehension
6. 5 % alcohol in glucose....	28	For apprehension
7. Repeated injection.....	47	Block disappeared before end of operation
8. Spinal.....	43	When bone grafts were taken from lower extremity
9. Superficial cerv. plexus block	12	For surgery of upper arm involving deltoid area
10. Bracelet at upper arm..	233	For surgery of upper one-third of the arm involving deltoid or medial aspect of arm or use of tourniquet
Total.....	516	

Whenever additional supplementary anesthesia was necessary because of total failure of the block, pentothal-nitrous oxide-oxygen or any other available general anesthesia was used. If only part of the plexus was anesthetized and time was

gardless of the supplementary technic, it is very important to have the patient feel no pain. (Tables IV, V and VI.)

In the earlier cases 2 per cent procaine was used exclusively, except in a few cases in which it was considered advantageous for the patient to retain some motor power in order to help the surgeon identify tendons. In these cases 1 per cent procaine was used. Later 1.5 per cent metycaine was used and it was found to be of longer duration. In July, 1946, an article by Brown et al.,<sup>32</sup> advocating the use of dilute pontocaine solution for continuous causal anesthesia, suggested its use in all forms of regional procedures including brachial blocks. They presented figures which were quoted by Saklad<sup>34</sup> from the work of Novak on the comparative potency and toxicity of procaine, metycaine, pontocaine and nupercaine which are reproduced in Table VII.

These figures were impressive because they corroborated our clinical experience obtained from the use of all these agents in spinal anesthesia. It is important to note that the ten-fold increase in the potency of pontocaine more than offsets the six-fold

TABLE V  
ADDITIONAL SUPPLEMENTARY ANESTHESIA

Agent or Technic	Partial Failures		Complete Failures	
	No. Cases	Per Cent	No. Cases	Per Cent
1. Pentothal-N2o-o2....	38	74.0	28	73.7
2. N2o-o2-ether.....	0	0.0	5	13.2
3. Nerve blocks (ulna, median, radial, at elbow).....	1	2.0	2	5.2
4. Wrist block.....	0	0.0	1	2.7
5. Infiltration.....	12	24.0	2	5.2
Total.....	51	100.0	38	100.0

available, the unanesthetized nerve was blocked at the elbow or wrist or infiltration anesthesia was used. If this was inconvenient, a general anesthetic was given. Re-

TABLE VI  
AGENTS USED

Agents Used	No. Cases	Dosage Used			Reactions	
		Maximum	Minimum	Average	Severe	Minimal
Procaine 1%.....	11	80 cc.	18 cc.	60 cc.	0	0
Procaine 2% (J.J.B.).....	560	125	8	46.6	3	2
Procaine 2% (D.C.M.).....	150	80	40	60.0	2	4
Pontocaine 0.15% (J.J.B.).....	74	70	15	40.6	0	0
Pontocaine 0.15% (D.C.M.).....	145	125	50	88.0	1	2
Pontocaine .10%.....	62	80	40	54.0	0	0
Pontocaine .075%.....	5	40	25	30.0	0	0
Metycaine 1.5%.....	27	40	25	39.0	0	0
Pontocaine .15% } Procaine 1% }	10	100	40	65.0	0	0
Intracaine 1.5%.....	1	40	40	40.0	0	0
Intracaine 5% in oil.....	3	15	15	15.0	0	0

The cases done with 2 per cent procaine and 0.15 per cent pontocaine have been segregated to show that different amounts of the drugs have been used by two separate groups with the same end results. The maximum dose of 125 cc. of 2 per cent procaine was not used in a single injection but in three subsequent injections used by continuous technic.

increase in the absolute toxicity compared with procaine, giving pontocaine a corrected toxicity ratio of 0.58.

We started to use dilute pontocaine solutions for brachial blocks hoping to increase the duration of anesthesia. In the first few

TABLE VII  
COMPARATIVE FATAL INTRAVENOUS DOSE OF LOCAL ANESTHETICS IN CATS (NOWAK)

Local Anesthetic	Av. Fatal Dose (mg./Kg.)	Ratio Compared with Procaine	Equivalent Dosage Ratio	Corrected Toxicity Ratio Compared with Procaine
Procaine.....	49.6	1.0	1.0	1.0
Metycaine.....	28.8	1.7	0.8	1.36
Pontocaine.....	8.6	5.8	0.1	0.58
Nupercaine....	3.5	14.2	0.05	0.71

cases 50 cc. of 0.15 per cent (75 mg.) pontocaine with epinephrine 1:200,000 was used, which has a corrected toxicity ratio of 0.44

tions as similar as possible, three experienced anesthesiologists performed all the blocks without selection of cases, using the one needle technic with paresthesia. The three drugs were used consecutively and the same amount of solution was used to eliminate the variation due to bulk and dosage. Exactly 40 cc. of 2 per cent procaine or 1.5 per cent metycaine or 0.15 per cent pontocaine was used with epinephrine 1:200,000. The time the block was completed was recorded as zero hour and then the attendant carefully observed the effects of the block, such as sympathetic block, loss of pain, proprioception and touch, loss of motor power and signs or symptoms of toxicity. Postoperatively the blocks were followed by the same attendant and charted. A summary of the results is presented in Tables VIII and IX. Table VIII shows the time necessary for the loss of pain and touch sensation and motor power. Table IX shows the time that analgesia was present. These figures clearly show that the duration of anesthesia due to pontocaine is

TABLE VIII  
TIME FOR ONSET OF ANESTHESIA

Agent Used	No. Cases	Time for Onset of Anesthesia (in minutes)								
		Pain Loss			Touch Loss			Motor Loss		
		Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
2% Procaine 40 cc.....	50	33	5	16.4	53	5	24.0	42	10	19.5
0.15% Pontocaine.....	50	35	5	23.3	45	5	34.3	50	5	26.6
1.5% Metycaine.....	25	32	3	12.0	52	12	19.0	35	8	16.0

(if it is assumed that the equivalent dose of procaine is 50 cc. of 2 per cent). The results startled us for in the first three cases the average duration of anesthesia was six hours and forty-three minutes. It was decided to run a very carefully controlled series of cases in order to compare 2 per cent procaine, 1.5 per cent metycaine and 0.15 per cent pontocaine for brachial plexus block anesthesia. In order to make condi-

several times that of the other drugs and without any apparent increase in toxicity. As a matter of fact, it is our conviction that dilute pontocaine solutions cause less toxic reactions even when given in large amounts. Moore<sup>34</sup> has used up to 125 mg. of pontocaine in a large number of cases requiring regional anesthetic procedures, without any evidence of toxicity. This corroborates the work of Brown et al.<sup>32</sup> and

James.<sup>35</sup> The latter administered as high as 2 mg. of pontocaine (amethocaine) per pound of body weight without observing any toxic effects. This prolonged action of pontocaine offers many advantages to the regional anesthetist. It obviates the need

It is important to emphasize at this point that by these illustrations we do not advocate administration of a block and then forgetting the patient. Whenever it is necessary to block these patients ahead of time, they should be under the observation

TABLE IX  
DURATION OF ANALGESIA

Drugs	No. Cases	Dose, (cc.)	Duration of Analgesia		
			Minimum	Maximum	Average
0.15% Pontocaine.....	50	40	1 hr. 50 min.	12 hr. 50 min.	6 hr. 18 min.
2% Procaine.....	50	40	40 min.	4 hr. 5 min.	1 hr. 31 min.
1.5% Metycaine.....	25	40	60 min.	3 hr. 20 min.	1 hr. 56 min.

for additional anesthesia in long operations. It is a great comfort to the surgeon and anesthetist to know that the anesthesia will not disappear before the operation is finished. Our surgeons have shown their appreciation for this type of prolonged anesthesia by requesting it for all of the surgical operations of the upper extremity. It also allows the busy anesthesiologist to do regional anesthesia without undue waste of time. The following cases illustrate this well:

M. D. and J. B. were both scheduled for operations of the upper extremity with brachial block anesthesia for 10 A.M. The anesthetist had one case starting at 8 A.M. which would probably last until after 10 A.M. He therefore blocked M. D. at 7 A.M. and J. B. at 7:15 A.M., and observed them until 7:45 A.M. By this time perfect anesthesia without any signs of toxicity was evident in both cases and he was able to start his 8 A.M. case. Both patients were operated upon at 10 A.M. without any additional anesthesia. M. D. had anesthesia until 4:45 P.M. and J. B. was discharged at 3:30 P.M. without having had any postoperative sedation. At the time of discharge she still had complete anesthesia.

H. E. was scheduled for a 11 A.M. surgery. The same circumstances prevailed. He was blocked at 7 A.M., operated upon from 11:05 A.M. to 1 P.M. and had complete analgesia until 5:15 P.M. He required only one postoperative "hypo" for the entire evening and night.

of some one, preferably in the anesthesia room during the preoperative period. Of course, during the operation the anesthetist should always be in attendance in case a complementary or supplementary anesthesia is necessary.

The patients appreciate this postoperative analgesia without the drowsiness, hypnosis and sometimes nausea which accompanies the usual general anesthesia and the postoperative sedation. Many of the patients expressed gratitude to the surgeon for this postoperative painlessness and many of them requested brachial plexus block for subsequent operations. This is well illustrated by the following case:

J. R. was a six year old private patient who entered the hospital for the first time on August 18, 1947, with a complete transverse fracture of the radius and ulna. With brachial block anesthesia the fracture was manipulated several times in the fluoroscopy room, a cast was applied and the patient was sent home. He returned the following day with repeated displacements of the bone fragments. Manipulation was again done with vinethene-ether anesthesia administered by a technician. The cast was reapplied and the patient sent home as soon as he was able to walk. The fracture again became displaced and on August 25th an open reduction with plating was performed with brachial plexus anesthesia. Six months

later the patient entered the hospital for removal of the plate. He specifically requested of the surgeon that he wanted a block and did not want to go to sleep. The next morning the plate was removed with brachial block anesthesia.

Such prolonged anesthesia is also of value in patients who have circulatory disturbances in the extremity as they benefit from the sympathetic block which accompanies the anesthesia.

Since the completion of the control series we have used pontocaine in many more patients requiring brachial plexus block and have used not only 0.15 per cent but also 0.10 and 0.075 per cent solutions. The latter dilution has been used whenever it is necessary for the patient to retain some motor power and also in children. The blocks on J. R. were done with 30 cc. of 0.075 with epinephrine 1:400,000. These dilute solutions do not cause anesthesia of the same duration but it is long enough for any operation.

#### COMPLICATIONS

The complications which we have encountered in these cases are tabulated in Table x. Pneumothorax was the most important of these complications although none of the patients who had it became distressed. All cleared up in a few days without sequelae.

Six severe toxic reactions occurred which were treated with pentothal and oxygen without any sequelae. Five of these occurred with 50 cc. of 2 per cent procaine. The others were of minimal nature and were cleared up without treatment although in many cases 50 mg. of pentothal were given in order to counteract them.

Four of the patients in this series had a transient and minimal degree of paresis and analgesia in the area supplied by the ulnar nerve. These occurred in hand cases operated by the same surgeon. Upon investigation it was found that the surgeon placed the arm on the table in a way which caused pressure on the nerve in the elbow. Upon change of position of the patient's arm in

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subsequent blocks done for the same surgeon no further complications were noted.

Puncture of the subclavian artery has occurred in many of the cases without any apparent complications. Of course, the needle was always withdrawn from the

TABLE X  
COMPLICATIONS

Complications	No. Cases	Per Cent of Total
Pneumothorax .....	9	0.82
Drug reactions		
(a) severe.....	6	0.55
(b) minimal.....	8	0.73
Transient ulnar nerve paresis.....	4	0.36
Miscellaneous.....	7	0.64
Total.....	34	3.1

artery before injecting. We have always tried to palpate for hematomas following the puncture, particularly in thin individuals, and have not been able to discern any tumefaction.

Phrenic nerve block with consequent diaphragmatic paralysis of that side may occur, particularly if a large amount of solution is used, but we have not observed any signs or symptoms which would be related to its presence. In a small group of patients roentgenograms were taken which failed to show any paralysis of the diaphragm. Bilateral brachial plexus block was used in two patients without any subjective or objective disturbances of respiration or circulation.

Cervicothoracic (stellate ganglion) sympathetic block has been observed in some of the cases.

#### SUMMARY AND CONCLUSIONS

1. The many advantages of brachial plexus block anesthesia have been reemphasized.

2. All American literature on the subject has been reviewed.

3. Several points in the "anesthetic" anatomy of the plexus have been stressed.



4. Eleven hundred brachial plexus blocks performed by thirty-four anesthesiologists for 1,048 operations are reported with a brief description of the technics used.

5. Perfect anesthesia was obtained in 91.9 per cent of the cases. Of the rest, 4.6 per cent had partial anesthesia and 3.5 per cent had no anesthesia.

6. Procaine, metycaine and pontocaine in different concentrations were used.

7. A vasoconstrictor was added to all solutions. Epinephrine in concentration of 1:200,000 was used in adult patients, while in children the concentration was 1:300,000 or 1:400,000.

8. The use of 2 per cent procaine, 1.5 per cent metycaine and 0.15 per cent pontocaine in a controlled series of cases are reported and analyzed. Pontocaine caused the longest anesthesia with an average duration of over six hours without any increase in toxicity.

9. The complications and difficulties encountered are reported.

10. From the results obtained in this series of cases, it is evident that brachial plexus block is an adequate form of anesthesia for any operation of the upper extremity and that with proper instructions, a thorough knowledge of anatomy and observation of certain principles any operator is able to obtain good results. It is hoped that more doctors take advantage of this adequate form of anesthesia in the future.\*

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To find the effect of anesthesia and surgery on tuberculosis Parke et al. studied almost 300 patients in none of whom was major chest surgery done but in all of whom other operations were indicated and performed. When the tubercular patient was in an arrested state, as was true in over 10 per cent of these cases, anesthesia (of any type) and surgery did not produce an extension of the patient's pulmonary tuberculosis. However, especially when the patient had extensive pulmonary tuberculosis and positive sputa tests, Parke et al. found that postoperative extension of the patient's present pulmonary status is to be expected. Although the series is short (actually only 282 cases), the evidence points to the aforementioned conclusions and the authors are well justified in warning surgeons of possible hazards and complications in operating on such patients. Thus if a patient with active tuberculosis has chronic appendicitis or chronic cholecystitis, a hernia or any other surgical condition which does not require immediate surgery, the surgeon will be wiser to delay operation until the patient's pulmonary condition becomes arrested. (*Richard A. Leonardo, M.D.*)

# INJECTION OF MANDIBULAR NERVE AND GASSERIAN GANGLION

## AN ANATOMIC STUDY

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ALCOHOL injection of the gasserian ganglion has been used for the relief of trigeminal neuralgia since the beginning of this century. There are two principal methods: One is the ascending route first used by Schlösser.<sup>1</sup> His method was followed and modified by others.<sup>2-14</sup> All these authors have used the extrabuccal ascending route except Ostwalt who started his injection through the mucous membrane of the mouth (intra-buccal ascending route).

The other method is the horizontal or transzygomatic route. This was first used by Lévy and Baudouin.<sup>15</sup> It was repeated with slight variations by other operators.<sup>16-26</sup>

### TECHNIC OF HORIZONTAL TRANS- OR SUB-ZYGOMATIC METHOD OF INJECTION

The aim is to inject the mandibular division of the trigeminal nerve at the point of its exit from the foramen ovale. A straight needle 10 cm. long and 1.0 to 1.5 mm. in diameter is used. Some operators use it fitted with a blunt stylet, others without a stylet. The needle is marked in centimeters from the point up to five so that the operator may know what depth he has reached.

The skin is prepared and anesthetized in the usual manner. The needle is inserted through the cheek behind the last upper molar at the lower border of the zygoma 2 to 2.5 cm. in front of the descending root of the zygoma, which can always be felt as a ridge close to the anterior bony border of

the external auditory meatus. After the needle has pierced the skin the blunt stylet, when used, is pushed home and the deep tissues are penetrated with a blunt-ended instrument without injuring the deep vessels. The needle is directed slightly upward and a little backward hugging the base of the skull until it reaches the mandibular nerve at its exit from the foramen ovale at a depth of about 4 cm. from the zygoma. This depth varies slightly, depending upon the shape of the head and the thickness of soft parts, but it is never greater than 5.5 cm. from the surface. If difficulty is encountered in passing through the sigmoid notch of the mandible, it may be overcome either by having the patient's mouth wide open or by depressing the handle of the needle slightly. The needle passes through skin, subcutaneous tissue, masseter muscle, posterior portion of the temporal tendon, superior border of the external pterygoid muscle and anterior to the temporomandibular joint.

Frazier<sup>23</sup> and Grant<sup>24</sup> used an instrument called a zygometer. The use of this instrument, they thought, eliminated the uncertainty of being able to feel the descending root of the zygoma, thus making the point of needle puncture more accurate. Grant<sup>24a</sup> selected the 2 cm. mark in the lower bar of the zygometer in the standard position for the injection of the mandibular nerve. This corresponds approximately to the point of election described by Lévy and Baudouin.<sup>15</sup> In Grant's 162 injections on eighty-one cadavers the horizontal angle averaged 91 degrees and

the vertical angle 108 degrees. The nerve was reached at a depth of 4.5 cm.

De Froe and Wagenaar<sup>25</sup> found the pterygospinous foramen of Civinini in 5 per cent of European skulls. They mention that Haertel erroneously thought that the presence of such a foramen could prevent the injection of the semilunar (gasserian) ganglion of the trigeminal nerve through the foramen ovale. They point out that the presence of the partially or completely ossified pterygoalar ligament (ligamentum crotaphitico-buccinatorium of Hyrtl) can really make the injection of the semilunar ganglion impossible. My examination of 6,000 skulls<sup>27, 27a</sup> confirms their observation.

The roentgenologic technic of De Froe and Wagenaar<sup>25</sup> has made it possible to exclude poor results with certainty. They give credit to Haertel for the first successful visualization of the foramen ovale in the skiagraph of the base of the skull. According to them Götze also used the roentgenologic examination of the foramen ovale successfully.

They describe Haertel's technic and an improvement of it by Brücke for the x-ray examination of the foramen ovale. deFroe and Wagenaar<sup>25</sup> show roentgenograms of the foramen ovale with and without the presence of the ossified pterygospinous and pterygoalar ligaments.

Sunderland<sup>26</sup> describes a "pterygospinous bar," but apparently he does not distinguish between the pterygospinous bar and the pterygoalar bar which are two definitely separate and different entities. The former completes the pterygospinous foramen of Civinini while the latter completes the pterygoalar foramen (porus crotaphitico-buccinatorius of Hyrtl). His figures v and ix illustrate the last mentioned bar which makes the introduction of the injection needle into the foramen ovale by the horizontal transzygomatic route impossible. His figure iv represents the pterygospinous bar which, as he states, offers no obstacle for the passage of the needle into the foramen ovale.

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#### TECHNIC OF ASCENDING INTRA- OR EXTRA- BUCCAL METHOD OF INJECTION

Apparently Schlösser<sup>1</sup> was the first to use this method. He did not describe his technic in detail. Hecht<sup>4</sup> learned this method from Kiliani<sup>3</sup> who in turn was personally instructed by Schlösser. Hecht<sup>4</sup> described deep injection of the mandibular nerve at the foramen ovale by Schlösser's method as follows: "Having first introduced his fingers into the mouth back of the last molar as a guide, he forces the longest one of his three especially devised needles through the cheek, (extrabuccal) under the periosteum to the pterygoid plate and upward on it until about 2½ inches of the needle are buried; lowering the handle of the needle admits of advancing the point about another one-fourth inch toward the base, where it is held in place. Then deftly feeling the way backward, and keeping closely to the bone for about half an inch, one feels the needle enter the foramen ovale and the injection is begun. Narcosis is hardly ever necessary, and should be omitted in order to get the benefit of the patient's appreciation as to any sensory change following the injection."

Ostwalt<sup>2</sup> claims to have improved upon this method in some essential points. He uses a bayonet-shaped needle and introduces it directly behind the upper third molar (intrabuccal). He pushes it through a rather thick submucous tissue and the external pterygoid muscle, or around its lower border to the external pterygoid plate. Then he moves the needle slowly and carefully upward until it reaches the infratemporal surface of the great wing of the sphenoid bone. He then slides the point of the needle backward between the infratemporal surface and the external pterygoid plate as long as bony resistance is felt. As soon as this resistance ceases the needle has entered the foramen ovale.

Haertel's approach<sup>5</sup> to the gasserian ganglion through the foramen ovale is practical and useful. His method is an improvement over the method of Schlösser.

Haertel points the needle to the pupil of the eye on the same side. The location of the foramen ovale is at a point on the base of the skull where a perpendicular plane through the center of the pupil and a horizontal plane through the articular eminence bisect. He takes roentgenograms of the patient's skull in a certain position to see the location and shape of the foramen ovale and to find out if there are any bony anomalies which might obstruct the passage of the needle into the foramen ovale.

Grinker<sup>6</sup> uses Haertel's method. He describes his own technic but his description is not very clear.

Under the fluoroscope Pollock and Potter<sup>7</sup> introduce a catheter into the eustachian tube as a guide for the location of the foramen ovale. They conclude that "employing the shadow cast by the anterior border of the petrous portion of the temporal bone, on a fluoroscope, as a line of orientation injection of the gasserian ganglion by Haertel's method is made more certain."

In Braun's book, translated by M. L. Harris,<sup>8</sup> the technic of injection of the gasserian ganglion is essentially the same as that used by Haertel.

Irger<sup>9,29</sup> uses a needle 10 to 15 cm. long and 0.8 mm. thick. The needle is furnished with a bar which could be replaced by a cork. He measures from the point of the needle to the bar a distance equal to that from the angle of the mandible (the mouth of the patient being closed) to the upper margin of the articular tubercle. He introduces the needle into the skin touching the medial side of the angle of the mandible. It is then slowly advanced to the bar following the direction of the skull base. It is to be noted that the articular tubercles and the oval foramina are upon one line. The longitudinal direction of the needle must coincide with the line uniting the puncture point with the upper margin of the articular tubercle.

According to Morris,<sup>10</sup> Haertel inserted the needle at about the level of the second upper molar, guiding it with a finger in the

mouth until the point of the needle reached the area of bone in front and lateral to the foramen ovale. He considered this surface of the bone "so characteristically hard and smooth that it could be used as a landmark to the foramen, which was the first depression or irregularity met with on it in working the point of the needle backwards." In this way he was able to locate the foramen ovale with accuracy.

Morris<sup>10</sup> states that, "the (mandibular) nerve may run deep to the accessory ossifications in this region, and at a depth which makes its safe infiltration with alcohol impossible."

Morris<sup>10</sup> makes the skin puncture 1 to 2 cm. lateral to the angle of the mouth or 2 to 3 cm. above this point, the former being referred to as the "vertical" type, the latter as the "horizontal" type. He guides the point of the needle between the buccinator muscle and the mandible on the infratemporal surface of the sphenoid bone, and with the aid of this surface and of the adjacent external pterygoid plate localizes the foramen ovale.

Souttar<sup>11</sup> inserts the needle into the cheek 1 inch external to the angle of the mouth, directing it upward and inward toward the lambda, the point on the skull where the lambdoid and sagittal sutures meet. After passing through the cheek, the needle enters the internal pterygoid muscle on the inner side of the coronoid process. Leaving this, it enters the external pterygoid and comes to rest at the root of the external pterygoid plate just in front of the foramen ovale and on the base of the skull. The needle is now partly withdrawn and directed slightly posteriorly to its former line, when the point should pass through the foramen ovale into the ganglion. The lambda, he claims, is his own landmark. It is easily felt as a depression on practically every skull; and if the index finger of the left hand is placed on this point, it will be found a very easy matter to direct the needle toward it.

Horrax and Poppen<sup>12</sup> use essentially the approaches to the foramen ovale described

by Haertel and by Harris. Their statement that "the foramen ovale lies just posterior and slightly medial to it (external pterygoid plate) (Fig. 3)" is obviously in error, for a careful study of this figure in their article, as well as my examination of skulls, shows that the foramen ovale lies just posterior and slightly *lateral* not medial to the external pterygoid plate.

Putnam and Hampton<sup>13</sup> apply practically the same technic employed by Haertel.

W. Harris<sup>14</sup> states, "... the lateral route through the sigmoid notch is often less satisfactory for injecting the ganglion than it is for the third division alone, owing to the difficulty in many cases of getting the needle to pass through the lips of the foramen." He states further: "Although I used this route for a number of years, for the last three or four years I have adopted for preference the anterior route that was described many years ago by Haertel, which, although it is longer, has the advantage of being a much steeper approach, so that there is no difficulty in passing the needle through the foramen. It is, however, in my opinion a route that required much more experience than the lateral route." In general the method is similar to the extrabuccal route of Haertel.

W. Harris<sup>20</sup> in the last thirty years has treated over 2,500 cases of trigeminal neuralgias mostly by alcohol injections. Therefore, he believes and justly so, that an analysis of his results "may be useful in establishing the value and limitations of this method."

#### COMMENT

From the foregoing description it is obvious that there are two principal methods of injection used in the treatment of mandibular neuralgia. One is the horizontal or transzygomatic route, the other is the ascending method. The former method is comparatively easy to master, but the latter needs more experience and skill. It is, however, anatomically impossible to use the horizontal method in a certain per-



FIG. 1. Base of skull. 1, pterygo-alar bar; 2, one end of white paper is inserted into the petrogy-alar foramen (porus crotaphitico-buccinatorius of Hyrtl) under 1; 3, foramen ovale; 4, foramen lacerum.

centage of cases due to the presence of a bony bar which completes the pterygo-alar foramen (porus crotaphitico-buccinatorius of Hyrtl), Chouké.<sup>27, 27a</sup>

Both these methods were tried on 100 embalmed cadavers. It was very easy to reach the foramen ovale by the horizontal transzygomatic route, except when the pterygo-alar foramen was present.

The foramen ovale was entered by the ascending method of Haertel only after many trials, but in no case was the presence of the pterygo-alar foramen responsible for failure of this method.

Since the publication of my two papers on the subject, I have examined 1,711 additional skulls bringing the total number of skulls observed to 6,000. In these 6,000 skulls the pterygo-alar foramen was complete 463 times (7.72 per cent). It was incomplete in 659 (14.79 per cent) of 4,456 skulls.

The pterygo-alar foramen, when present, is formed by a bar of bone running from the root of the lateral lamina of the pterygoid process of the sphenoid to the under-surface of the greater wing of the same bone. (Fig. 1.) Its presence forms an obstruction in the path of the needle inserted by the horizontal transzygomatic route and intended to reach the foramen ovale for injecting the mandibular division of the

trigeminal nerve or the gasserian (semilunar) ganglion. Quite often this bony bar is very strong and heavy. In dry skulls having the bar one cannot even see the foramen ovale from the lateral side much less pass a needle into it. In a living person presence of the bar would preclude using the horizontal approach. In cases in which the aforementioned bony bar is thin, one can see the foramen ovale in a dry skull but the passage of the needle is still impossible.

In the presence of such a bony bar the ascending route, originated by Schlösser and improved upon by Haertel and others, affords a means for entering the foramen ovale without obstacle. However, this method requires more experience and skill. It is apparently for this reason, although he did not say so, that W. Harris<sup>30</sup> after making injections into the foramen ovale in over 1,400 patients has now adopted the modified Schlösser's ascending technic of injection in preference to his own horizontal transzygomatic method.

Recently De Froe and Wagenaar<sup>25</sup> perfected a roentgenologic technic whereby they can visualize the foramen ovale and the presence or absence of the pterygo-alar foramen. In this way they can reach the foramen ovale with certainty. It would seem possible that one could inject the mandibular nerve or the gasserian ganglion under the fluoroscope, thus avoiding all uncertainties about endangering other structures.

#### SUMMARY

Two principal methods have been described for injecting the mandibular division of the trigeminal nerve or the gasserian (semilunar) ganglion; one is the horizontal transzygomatic route and the other is the ascending route started in the skin near the angle of the mouth. In about 8 to 10 per cent of individuals an anatomic anomaly, pterygo-alar foramen (porus crotaphitico-buccinatorius of Hyrtl) is present. The presence of such an anomaly makes the horizontal transzygomatic method of injection physically impossible.

The presence or absence of another anomaly in the same region, namely, the foramen pterygospinosum of Civinini offers no barrier by either route to a needle directed toward the foramen ovale, for the axis of the foramen of Civinini is vertical and at about right angles to the horizontal axis of the pterygo-alar foramen.

The pterygo-alar foramen is found in a higher percentage of negroes than in whites.

For best clinical results in the treatment of trigeminal neuralgia by injection through the foramen ovale, it is suggested that the ascending approach be used, preferably under the fluoroscope when practicable.

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# CLINICAL MANIFESTATIONS OF THE SYMPATHETIC REFLEX ARC

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IN a paper read in June, 1947, before the American Association for the Surgery of Trauma I presented neurophysiologic evidence of the presence of a sympathetic reflex arc<sup>1</sup> and I then touched briefly upon its clinical significance. During the past several years we have read of individual suggestions by clinicians recommending sympathetic block for the relief of one or another obscure clinical condition. These suggestions, appearing isolated and totally unconnected, are further demonstrations of the clinical significance of the sympathetic reflex arc. This entire problem awaits an analytic and systematic interpretation in which all the little understood conditions would be presented as having a common etiology and, therefore, a common therapy.

To stimulate study and thought by the clinician who, in contrast to the laboratory investigator, observes at firsthand numerous manifestations of the reflex, I shall discuss briefly several clinical conditions in which the sympathetic reflex arc is of supreme etiologic importance.

**Crush Syndrome.** During London's 1941 air raids physicians found that victims whose legs had been pinned under timbers and masonry for several hours died mysteriously of kidney failure. This strange condition was called "crush syndrome." Injuries to the vessels of the crushed extremity reflected the blood vessels of the kidneys into spasm and thus caused anuria. A gradual increase in the blood pressure followed. This clinical syndrome has been studied intensively during the past few years by pathologists. While pathologists still talk about the release of toxic substances by crushing injuries to

the muscles of the limb and about some unknown muscle-endocrine mechanism responsible for the observed intense vasoconstriction and ischemia of the glomerular tuft, they agree that vasoconstriction of the kidneys is always present in the post-glomerular arterioles. The steady rise of the blood pressure is a result of this vasoconstriction. Experimental data are now available which confirm the early appearance of vasoconstriction in crush wounds as seen by Keele and Slome following release of complete ischemia maintained for four hours in an extremity of a cat.<sup>2</sup> Of course, one must admit that the vasoconstriction initiated and caused by a crushed or ischemic limb is limited not only to the kidneys but it is in the kidneys that this vasoconstriction manifests itself most alarmingly. Considering all these proven facts it is logical and scientifically sound that repeated sympathetic blocking should take preference over all other measures in the treatment of a patient with a crush syndrome. Vasodilatation of the kidney arterioles and glomerular tufts is the first clear-cut aim of the clinician. Not all of us handling traumatic surgical material will see many cases of a well expressed crush syndrome but all of us have seen many border line cases in which in more or less extensive injuries to an extremity the patient shows numerous unexplained complications of a systemic nature despite good, conventional care. It should be an established rule that along with the management of the injured limb, a prompt and repeated blocking of the sympathetic is a condition without which the management is deficient. This is especially true in patients with a labile sympathetic system,

the one with cyanotic, clammy hands who is subject to instantaneous vasospastic reactions.

*Cardiac Trauma.* Another field in which many individual observations have not been fully understood is the field of vasospastic heart disease. It is only through observations by the surgeon interested in trauma of the heart that we are learning how to analyze and systematize our clinical observations. When a traumatised heart is exposed for repair, the most difficult task is to control the irritability of the heart muscle. It was found that spraying the exposed heart with a solution of novocain relieves this irritability. The novocain, by blocking the sympathetics, abolishes the spasm of the numerous small blood vessels of the exposed myocardium.

Maguire and Friswold<sup>3</sup> noticed that a seemingly trivial wound piercing the right ventricle near the atrioventricular groove without damage to the left coronary artery will cause electrocardiographic tracings consistent with a diagnosis of anterior infraction in 100 per cent of the cases. These typical tracings disappeared in from seven to ten days. This is an observation which gives credit to the investigative minds of these surgeons in contrast to the average surgeon who usually is so preoccupied with the mechanical details of his job that important observations escape him. This observation, which is baffling to the cardiologist, to my mind is explained by the distribution of the sympathetic system in the heart. For a study of this subject I refer you to an excellent monograph by Mueller.<sup>4</sup> The heart muscle shows an abundant supply of nerve fibers in the pectinate muscles, the trabecula carneae and in the papillar muscles. Incomparably more abundantly supplied is the region of the heart along the coronary sulci and the atrioventricular groove. There the heart is thickly covered with widely ramified bundles of the sympathetic nerves for at least 1 inch to each side of the groove or sulcus. Therefore, even a seemingly trivial wound in the neighbor-

hood of the atrioventricular groove divides numerous sympathetic bundles causing an immediate and widespread spasm of the coronary ramifications with the typical electrocardiographic tracings. To some degree an analogous observation is seen in coronary disease when even a small ischemic area in the myocardium initiates a further spread through the sympathetic of a reflex spasm and leads to an aggravation of the disease. It is only logical, therefore, to suggest that measures aiming at vasodilatation through blocking of the sympathetic arc in the myocardium should follow immediately after the conventional administration of analgesics and oxygen in the treatment of coronary disease. Such a sympathetic block is not to be viewed as a pain-relieving measure only as it is at present. It also follows that whenever time permits, a sympathetic block should precede any surgery on the myocardium.

*Postvagotomy Complications.* We now come to a field in which the role of the sympathetic reflex arc may be studied as a scientifically conducted laboratory experiment. With the enthusiastic support of Gragstedt, section of the vagus nerves for the cure of peptic ulcer recently acquired great publicity. This same operation was tried in Germany a quarter of a century ago and was discarded after several trials. As usual the enthusiasm of the proponents of this operation blinded them to the complications which follow this most drastic of surgical operations. Gradually reports appeared mentioning some quite unpleasant complications of the section of these most important vegetative nerves. But even in Chicago, the headquarters of vagotomy, no complications are known to the surgeons. In adjoining Minnesota and even among the stoic New England patients many and varied complications were noticed by the surgeons.

The gastrointestinal tract is innervated by both the sympathetic and parasympathetic systems. The parasympathetic system consists of the vagus nerves and of the splenic nerve which is the sacral divi-

sion of the parasympathetic system. The vagi supply the gastrointestinal tract down to the splenic flexure of the colon while the pelvic nerve supplies the descending colon. When the vagus nerves are cut in the chest or about their exit from the thorax, the sympathetic system is left without an antagonist from the stomach down to the splenic flexure of the colon. The postvagotomy complications naturally are the result of sympathetic irritability. In other words we are dealing with a sympathetic reflex arc which is as unimpeded as the knee jerk in an upper neuron lesion. Irritations, which under normal conditions would become neutralized by the antagonistic action of the vagus, lead to serious complications in the absence of this antagonist.

I had almost no experience with postvagotomy complications until May, 1947, when a vagotomy was done upon myself in the course of an esophagectomy, playing havoc with my digestion. Of course, I have studied my postvagotomy complications with greater care and interest than is usually the case in a follow-up clinic or in cases in which the busy surgeon leaves this study to one of his junior assistants.

Immediately following the vagotomy a number of complications appear which confuse the patient. After a few weeks the complications assert themselves and crystallize. In my own case they have continued with some brief intermissions for the past twelve months. These complications appear in episodes or bouts and are more frequent in cold or damp weather. Exposure or chilling of the long thoracotomy scar immediately reflects in a new bout of eructations, regurgitations, nausea, occasional vomiting of white, foamy, gastric secretion, abdominal distention and pain in the right lower quadrant and throughout the lower abdomen. The eructation and regurgitation result from a dilation of the stomach through contraction of the pylorus by the inhibiting action of the sympathetic system. Inhibition of the movements of the small gut and the

proximal two-thirds of the colon by the sympathetic leads to stasis. The overfilled, small gut causes pain typical of an intestinal obstruction with loud borborygmus. This may persist for days until a whistling sound of escape of intestinal gas through the splenic flexure of the colon gives full relief. This terminates the episode but not for long. An exposure to cold of my frost-bitten finger or even an arduous argument or outburst of temper again reflects in a new bout of sympathetic crises. During the bout, turning from my back to my side and the consequent falling of the intestines to the dependent side, immediately exacerbates the pain. This is then accompanied by profuse perspiration (a sympathetic reaction), chill and tingling of the skin. Even loud talk and noises of various kinds increase the colicky abdominal pain.

From studying my own case I wish to state most emphatically that vagotomy is a highly expensive surgical procedure. The price the patients pay is entirely out of all proportion to the disability caused by the peptic ulcer. I believe that even in esophagectomy the surgeon should make a real effort to save the vagus nerves.

#### SUMMARY AND CONCLUSIONS

I have spoken here about the role of the sympathetic reflex arc in a number of important little understood conditions. As we have seen, the underlying disturbance of the crush syndrome is renal vasospasm and subsequent anuria. Recently clinicians have reported rapid control of eclampsia by means of sympathetic block achieved by spinal or high caudal anesthesia. This observation supports the suggestion that the pathologic physiology of eclampsia is mainly sympathetic vasospasm of the kidneys. Another recent observation is that paravertebral sympathetic block relieves the swollen hands and feet, muscle spasm and tenderness of polio victims. While we know that spasm is not the most damaging effect of the disease, it is logical to believe that a sympathetic block will accomplish more

with less in relieving this spasm than the time and effort-consuming Kenny method.

In my paper before the American Association for the Surgery of Trauma last year I expressed the view that the presupposed decussation in the pons cerebri of *all* post-ganglionic sympathetic fibers destined for the blood vessels is not borne out clinically. Recently Gilbert and de Takats, in treating cerebral vascular insult (another manifestation of vasospasm) with blocking of the sympathetic in the Stellate ganglion, insist upon blocking the ipsolateral ganglion.<sup>5</sup> This observation is in direct support of my view on decussation of the sympathetic fibers. Thus clinical observations are again at variance with the views expressed by neuro-anatomists and physiologists.

I have tried to give a few high spots of the field of pathologic physiology centering about the sympathetic reflex arc. It is an enormous field which requires intensive study, analysis, correlation and systematization.

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# Streamlined Articles

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## FACTORS WHICH INFLUENCE MORTALITY IN DUODENAL AND GASTRIC SURGERY\*

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**D**RAGSTEDT'S work has focused attention again on the subject of duodenal and gastric ulcer.<sup>18</sup> His work is epochal and brilliant. We had hopes that out of his observations would arise a new and more hopeful period. Proper evaluation, however, will not be possible for several years.

In the meantime, partial gastrectomy is the most satisfactory operation at our disposal. The specter of high mortality, however, is still present in any but the most expert hands. The writer has had an experience of over 500 partial gastrectomies and has reduced mortality to less than 5 per cent. Indeed, the last sixty operations were performed without a death. In order to assist others also to lower mortality, it is believed that a statement of the factors influencing mortality should be worth while.

It must be remembered that these patients suffer chronically from dehydration, malnutrition, deficiency states, poorly functioning liver, kidneys and bowels in varying degrees; and often the heart itself may be deficient in reserve. The habit of admitting a patient one day and operating the next must be deplored. He must be kept long enough to allow a careful laboratory study, and sufficient time must be taken to treat the above conditions and to insure good renal and hepatic function. This will take a minimum of a week and preferably longer.

### PREOPERATIVE CONSIDERATION

Routine blood count, hemoglobin, hematocrit, urinalysis and Wassermann tests

are ordered. Also ordered are serum protein, albumin-globulin ratio, nitrogen, chlorides and carbon dioxide combining power. Electrocardiograms are requested.

Dehydration may be quite marked in this type of patient. This subject is adequately covered by many others.<sup>1,2,3</sup>

*Serum Proteins.* Hypoproteinemia must simultaneously be corrected. It is also frequently present in this type of case. Its effect is widespread on the general economy and welfare of the patient. It has been pointed out that the viscosity of serum proteins is essential to hold fluid in the blood stream. Adequate proteins, therefore, prevent edema in the gastric wall. If this is present at the time of surgery, the tissues are friable, hold stitches poorly and may be the cause of leakage. In fact, surgery in the presence of edema is definitely hazardous. Edema may cause swelling and obstruction of the outlet of the stomach following surgery. Wound healing is also hindered by hypoproteinemia.<sup>9,10</sup> In addition, proteins are essential to the proper metabolism of the liver and act as a buffer there. It is well known that the liver stands the toxic effect of anesthesia better if well supplied with proteins.<sup>11</sup> Proteins are also essential for their nutritive value. While carbohydrates and fats are also necessary, proteins are of the utmost value to build up tissues.

The most rapid method of building up serum proteins is by the administration of blood plasma and whole blood. Amino acids given intravenously will build up the pro-

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teins more slowly. Many surgeons have used amino acids intravenously and have been disturbed by severe reactions in their patients. If the solution is run in slowly, taking from two to three hours' time, very few reactions will be encountered.

Sodium chloride is often depleted by excessive loss as in vomiting or in gastric suction. This loss must be compensated if we expect the normal urinary output.

Glucose solutions should be given<sup>12,13</sup> since these patients need calories and the liver needs an adequate supply to build up reserve of glycogen. If a sufficient amount is not administered, the proteins and fats will be used up. The latter will not be properly oxidized and results in acidosis.

*Vitamin Deficiency.* Vitamin deficiency must be treated as it is present in practically all cases. Its effect on the general well being and on wound healing has been emphasized by G. H. Bourne<sup>14</sup> and by Bartlett, Jones and Ryan.<sup>15</sup>

*Preoperative Care of Obstruction of the Duodenum.* Where there is obstruction to the pylorus, there usually is considerable edema in the stomach wall. If operation is attempted, this edema materially adds to the danger of leakage. Continuous drainage of the stomach for at least four days reduces this edema and is absolutely essential. One can add that the electrolyte balance must be watched and the amount of chloride loss replaced.

#### OPERATIVE CONSIDERATIONS

*Choice of Operation.* Operations have run the gamut from simple excision of the ulcer, pyloroplasties, gastroenterostomy, pylorotomies, followed by gastroduodenotomy and, finally, partial gastric resection. We use a simplified Polya resection by the anterior route, described and published in 1940.<sup>19</sup> The method is an "open" technic using neither clamps nor cautery, believing that these cause damage to the tissues and delay surgery.

It is important to remove the duodenal ulcer when possible. It is our belief that more satisfactory results are obtained when

this is done. This is not easy in a high percentage of cases as the ulcer may be low and there may be considerable induration around it. We dissect as low as possible. Often identification of the common duct will assist in estimating how low we can proceed. Mobilization of the duodenum often is of value, then remove the mucous membrane with a scissors or even a knife, coring it out as is done with the cervix. By this procedure, we often can reach a much lower point in the duodenum than would be possible by external dissection and have been able to remove the ulcer or sew the lumen across below the ulcer area. Only by an open method could this be done.

The duodenum is closed with No. 000 chromic catgut and reinforced with interrupted silk. Usually this takes in the capsule of the pancreas and turns in the suture line effectively. Omentum is then sutured over this area. We cannot emphasize too much the safety of the open method of suture without the use of clamps or cautery. No peritonitis has ever been seen. Furthermore, we have had no case of leakage in the last ten years. (Figs. 1 to 5.)

We perform an anterior Polya operation routinely. When we find the omentum heavy and thick, we remove a section and then the jejunal loop may be brought up adequately without tension. We believe that the anterior method is the one choice as it can be accomplished with much more speed, is less likely to have mechanical complications and permits adequate resection. We remove at least two-thirds of the stomach. It is important to attach the jejunum so that the efferent loop leaves the greater curvature. We have found that the left lobe of the liver presses on the jejunal loop tending to kink it somewhat. This seems to be unimportant if the efferent loop comes off the greater curvature. No difficulties in emptying have been experienced since we began anastomosing in this manner.

Anastomosis to the full width of the stomach is performed. No clamps are used

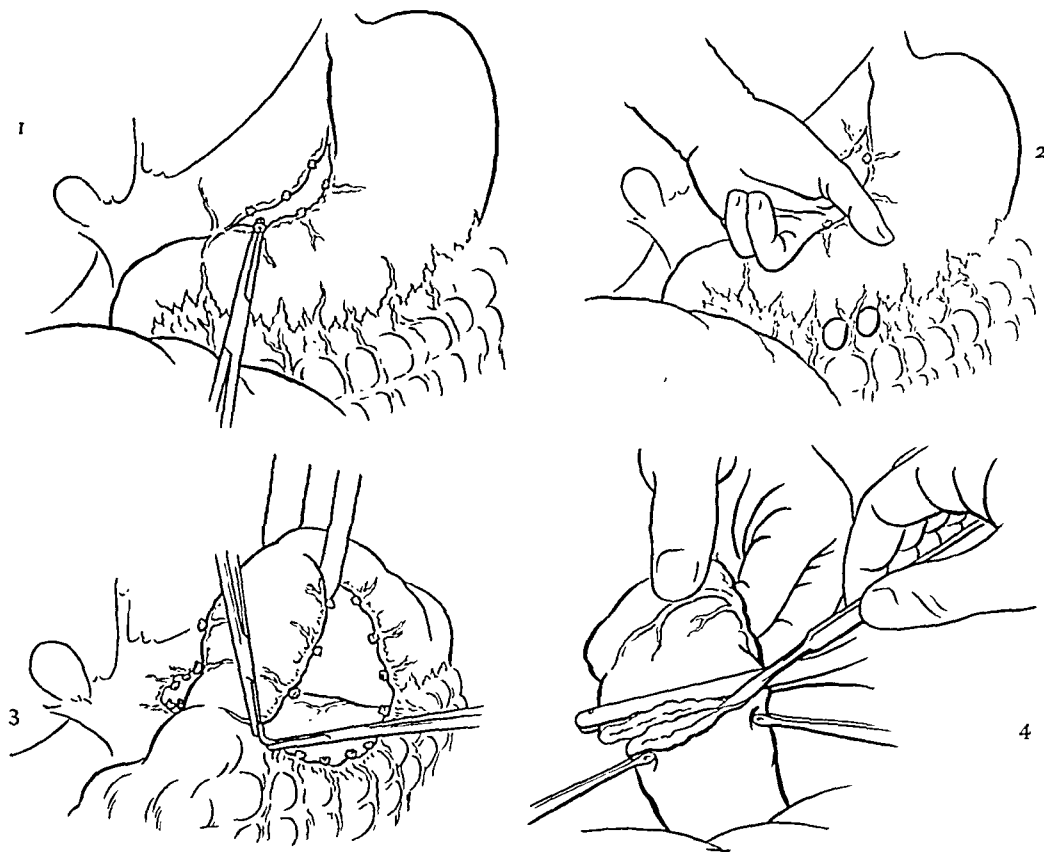


FIG. 1. The gastrocolic omentum is divided.

FIG. 2. The fingers are brought through the gastrohepatic omentum and out through the gastrocolic omentum.

FIG. 3. The gastrocolic omentum is divided and ligated.

FIG. 4. The duodenum is clamped with a Peyer clamp and divided openly below this point.

as these serve no useful purpose and, on the contrary, crush the tissue which has to be removed later. This is time-consuming and unnecessary. With no clamps applied the muscles of the stomach contract and

reduce the size of the transverse diameter so that the anastomosis is not unduly large.

We have little or no spillage as the stomach is sucked dry by a suction tip. No matter what method is used, the stomach has to be opened. No peritonitis has ever been experienced as a result of our open method.

The opening in the jejunum is curved down the two limbs toward the ends. When suturing is completed, this enlarges the openings somewhat. This we believe important.

Bleeding points are carefully caught up and tied separately with No. 000 chromic catgut. This makes a cleaner operation and insures against postoperative hemorrhage.

Anastomosis is accomplished by a running suture of No. 000 chromic catgut; then the stomach and jejunum are opened.

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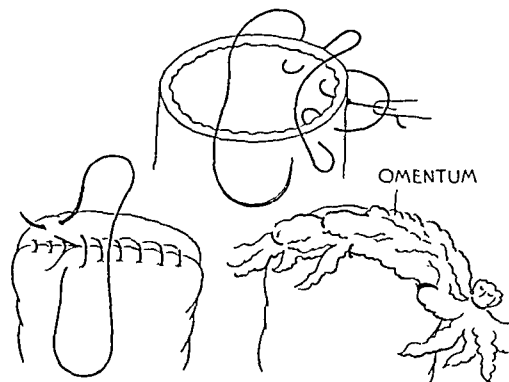


FIG. 5. The duodenum is closed with a Connell inversion stitch followed by a serous layer of catgut. A third layer of interrupted silk sutures is used and the area covered with omentum.

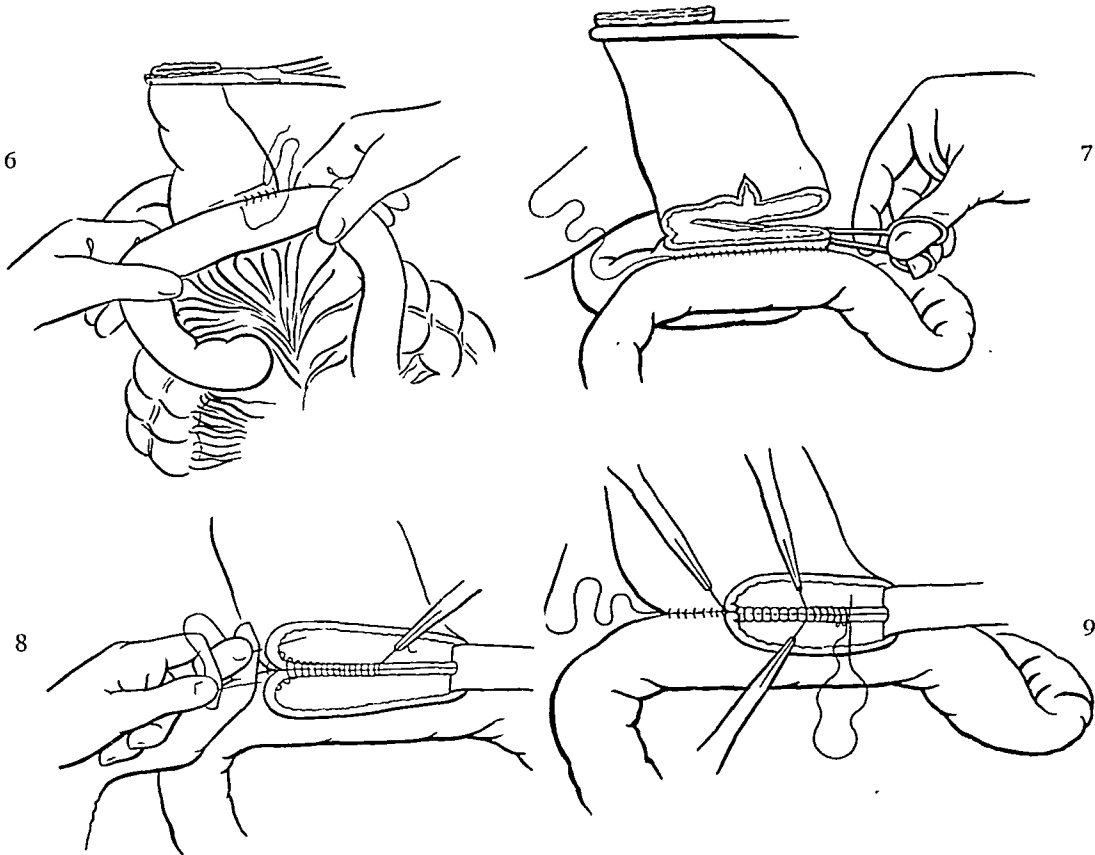


FIG. 6. A serous stitch is run; note that the proximal loop is at the lesser curvature.

FIG. 7. The stomach may now be resected; a corresponding opening is made in the jejunum.

FIG. 8. Suture is started in the center at the back and continued around the end so that no critical point exists.

FIG. 9. A second suture starts at the middle and is continued around the other end; these two sutures close the anterior edges, using a Connell inversion stitch.

The posterior line of sutures is begun in the center. This allows the suturing around the ends to be continued without interruption onto the anterior and does away with the critical points. The second suture is started at the same point on the posterior and is continued in the opposite direction and around the anterior edges to meet the termination of the first line of sutures. The serous suture is then continued around the anterior surface to complete the anastomosis. Only two layers of suture are used. These are continuous. No reinforcing with silk is used. No leakage has ever been experienced, and there is no necessity to use interrupted sutures as these are so time-consuming. (Figs. 6 to 10.)

This paper would not be complete without a word on the choice of incision. We use a transverse incision, curving with the

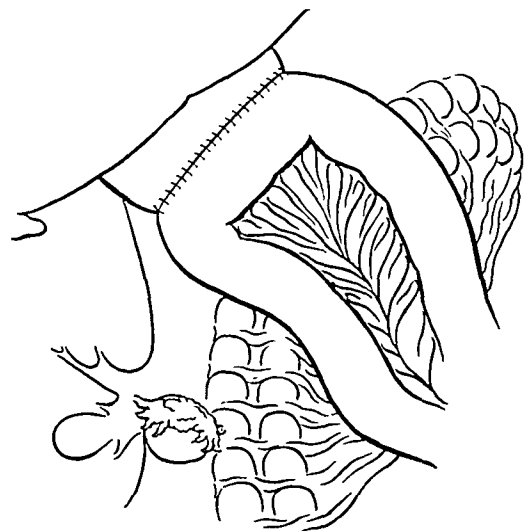


FIG. 10. The original serous stitch is now continued around the anterior to complete the operation.



configuration of the ribs. The rectus and the external oblique muscles are divided and retracted down and the deeper layers are divided at a somewhat lower level. Thus when they are sutured, the lines of stitching are at different levels or "staggered." This gives a strong wound which after use for several years has never disrupted. The eighth nerve is not divided but is retracted down and outward. This incision gives excellent exposure and little, if any, use of retraction is necessary during the operation. This also adds to the ease of working, allows more rapidity and is less shocking to the patient.

#### POSTOPERATIVE COMPLICATIONS

*Shock.* The best treatment of shock is its prevention. A well prepared patient will rarely exhibit severe shock. Whole blood is considered the best prophylactic. A blood transfusion the evening before is routine and 1,000 cc. of blood are given during surgery. Usually too little blood is used by surgeons and the author urges larger quantities. Spinal anesthesia is better than general anesthesia in prevention of shock. Rough handling and pulling on the stomach is a fruitful source of shock. A well planned simple operative procedure cuts down the length of the operation and minimizes the danger of shock. The transverse incision described is fruitful in preventing shock.

*Vomiting.* This is usually due to edema at the orifice and is attributed to hypoproteinemia. If this has been adequately controlled preoperatively, vomiting is rare. Indeed, now we never use a Levine (nasal) tube and it is rarely necessary to insert one. At the first sign, however, (usually regurgitation of a mouthful of stomach contents) a Levine tube is inserted into the stomach through a nostril. Sometimes a "hidden" dilated stomach is the cause of a sudden rise in temperature. Emptying the stomach will cause a dramatic drop in the temperature. After draining the stomach for a day or two, the Levine tube is removed.

If filling occurs again, we must consider

the possibility of edema at the stoma or organic obstruction by adhesions. In this case the Levine tube must be reinserted and left in. How long the case can be kept with the hope it will open up is a matter of great difference of opinion. We have repeatedly kept patients in relatively good condition for three weeks and, therefore, urge not to re-operate too hastily. We have operated upon such patients and found them well able to stand the shock. Other patients whom we feared would come to surgery made spontaneous cures. It may be stated that since the author has changed his technic to place the efferent loop of the jejunum at the greater curvature, he has had no complications of this nature.

*Postoperative Hemorrhage.* Again, the best treatment is prophylactic. Bleeding points in the submucous layer of the stomach are picked up and separately ligated at operation. This is particularly important in older people with sclerosed arteries. One should not rely entirely on the continuous catgut sutures to control such bleeding. When hemorrhage does occur, it manifests itself as regurgitation of black, foul-smelling material which should be immediately recognized as blood.

A Levine tube is inserted without delay and the stomach is emptied by siphonage. If a Connell suction apparatus is used, this should be lowered so that no strong suction is possible. We have seen this cause bleeding on many occasions and may be the reason for continuance of the hemorrhage. Blood transfusions not only replace the blood loss but assist coagulation by supplying thrombin, therefore, transfusions are routinely given. We have had no case in which surgery was necessary; so it is only reasonable to conclude that such is not indicated except in exceedingly rare cases. Operations under these circumstances carry a terrific mortality and must be undertaken only in those instances in which the bleeding is massive and continuous. Blood pressure taken and recorded every hour is of the utmost assistance in evaluating the severity of these cases.

It has been shown recently by Byrne M. Daly<sup>16</sup> that the reason thrombin given orally did not assist in stopping hemorrhage was that it is destroyed by the acid in the stomach. He recommends 60 cc. of M7 Phosphate buffer (P.H.7.8) followed by thrombin dissolved in phosphate buffer. Under these circumstances he believes that the thrombin would form a clot and assist in controlling the hemorrhage.

*Pulmonary Complications.* These are best treated by preventing their occurrence. Much can be accomplished along this line. Proper preparation of the patient is essential. Hypoproteinemia is an important cause of edema in the tissues and this includes the lungs. The improper administration of large amounts of fluids, especially in the aged, tends to cause overloading of the right side of the heart and decompensation ensues.

Morphine should be given at least an hour before surgery as it has been shown by Dr. Dripps<sup>5</sup> that the maximum effect does not take place until one hour and fifteen minutes. It should not be given in excessive doses. It is our desire to have the patient wake up quickly following surgery so that there may be active cooperation from the patient in coughing and clearing the throat of secretions. Too often the cough reflex is lacking due to oversedation following surgery.

The usual dose of atropine is insufficient. Doses of  $\frac{1}{100}$  gr. to  $\frac{1}{75}$  gr. more effectually controls secretion in the air passages. Haight and Rausom<sup>6</sup> point out that many patients suffer from postnasal drip. To prevent these and other secretions entering the trachea during operation the head should not be elevated on a pillow but should be lower than the body. Even a mild Trendelenburg position is recommended. If general anesthesia is given, an intratracheal tube should be used. At the end of the operation the bronchial tree should be sucked dry and the lungs fully expanded. It has been suggested<sup>6</sup> that a mixture of helium should be used for this

purpose since it is less readily absorbed and tends to keep the alveoli expanded.

After the patient is brought back to bed the foot of the bed should be elevated so that secretions are expelled by dependent drainage. Even this will not properly drain the posterior part of the lungs so that the patient *must* lie a good portion of the time on his side. He must not be left too long on one side lest the secretions from the upper lung run down into the lower lung. Changing position from one side to the other at least every thirty minutes is routine in our practice.

Hypoventilation often precedes atelectasis. The lungs, therefore, should be fully expanded by urging the patient to breathe deeply. This is assisted by frequent inhalations of pure carbon dioxide. It has been suggested that inhalations of helium and oxygen would be better.<sup>7</sup> The bronchial plugs produce obstruction but rarely is this obstruction complete. It is thought that helium, being a lighter and more readily diffusible substance, will get past these plugs when the heavier gases will not. Steam also materially reduces the viscosity of the secretions and makes it easier to expel them. A steam kettle, therefore, should be used routinely.

The voluntary cooperation of the patient is essential. Often they are afraid to cough and must be encouraged and urged to do so even if it does cause some discomfort. Strapping the wound tightly will allow them to cough without too much discomfort.

Atelectasis may occur in spite of all these measures. It is heralded by a sudden abrupt rise of temperature. Breath sounds are coarse, but not the same as the bronchial breathing of pneumonia. X-ray of the chest usually shows a typical consolidation. It must be pointed out that a negative x-ray does not rule out atelectasis as this may be concealed by the liver shadow. We plead for careful lung examination and the *early* recognition of atelectasis. If treated promptly, the condition usually yields quickly; but if not recognized, it may soon pass into a fully developed pneumonia and

the process becomes irreversible. Often physical findings are lacking and the patient may not appear ill, but plugging of the bronchi must be suspected when there is a sudden rise of temperature. Often we use a tracheal catheter and are astounded that 30 to 40 cc. of fluid are sucked out. This procedure irritates the trachea and stimulates violent coughing. We have taught the interns and residents to pass the catheter and it is easy to learn the technic. The effect is usually dramatic and the fever drops as rapidly as it ascended.

Atelectasis in the earliest stage may be simply treated by turning the patient on his good side and provoking a coughing spell by a good slap on the back. Voluntary violent coughing may also dislodge the plugs. When this occurs, the relief is dramatic. If this fails, intubation of the trachea by a nasal tube often gives the desired relief. If this is not quickly obtained, bronchoscopy should be performed. This is a definite and effective method and rarely fails to produce the desired results. It is surprising how little shock or inconvenience is caused the patient and should not be withheld on this contention. Again we urge all the above treatment be carried out *promptly*. "Observing" the patient until the next day definitely should not be permitted.

*Early Ambulation.* Early ambulation is now used by us. It prevents lung complications as the patient can cough when standing and is urged to do so. The patient can also urinate better and cystitis and pyelitis are prevented. He is urged to get out of bed the evening of his operation if his condition permits.

*Wound Infection.* This complication occurs rather frequently. We now protect the wound by placing cellophane, oiled silk or rubber tissue between layers of towels. At the completion of the gastrectomy these towels are removed. The surgeon and nurses put on new gloves and new instruments are used to close the incision; infection is now a rarity.

The author has no objection to using

sulfanilimide in the wound, but does not use it in the abdomen on the grounds that it is unnecessary and will produce massive adhesions.

The administration of 50,000 units of penicillin every three hours is routine. This not only guards against wound infection but is also protection against peritonitis and pneumonia.

*Wound Disruption or Evisceration.* When this occurs, it is indeed a serious complication and accounts for a considerable percentage of mortality. This condition will be much less frequent if sufficient vitamins, particularly vitamin C, have been administered preoperatively.<sup>17</sup>

Whatever the cause of evisceration, it is established that the wound will heal if held together long enough. The figure-of-eight tension sutures as ordinarily inserted are worse than useless. We have been using through-and-through sutures down to the peritoneum. These are tied over long rubber tubes in pairs on either side. Should evisceration be "attempted," these sutures may be tightened up. This obviates the necessity of putting in such sutures after evisceration has occurred. We have had no serious trouble since this technic was adopted.

Should disruption occur, however, mortality will be reduced by leaving the patient in his room and packing the wound with gauze and strapping tightly with adhesive plaster. The wound is dressed every day but the deeper gauze is not disturbed until after the fourth day. The wound heals by granulation. Taking the patient to the operating room and suturing there carries with it a high mortality. The author uses a transverse incision and has never had one eviscerate. This has materially lessened mortality.

*Leakage from the Duodenal Stump.* This is an extremely serious complication. It may be suspected when the patient has a sudden severe pain accompanied by shock and rigidity of the abdomen. The abdomen must immediately be opened for drainage. No attempt should be made to re-suture

the stump. Drainage by Penrose drain, with a catheter running through it, and continuous suction through the catheter maintained by a motor-driven suction apparatus, keeps the area dry and assists healing.

We have not had a leakage from the duodenum for over ten years. This is attributed to the fact that we never do a suture over a clamp and never use cautery. The open method allows the use of the Connell inversion stitch which more adequately turns the duodenum in. By this method, too, no devitalized tissue is included in the line of suture as is necessary when the clamp method is used.

*Embolism and Coronary Heart Disease.* In 1945 the author performed fifty partial gastrectomies. Three deaths occurred in the series. All of these were due to vascular complications. One patient died from a sudden, massive pulmonary embolus on the eighth day as he was sitting up shaving himself and otherwise feeling fine. The other two were older men who had recovered nicely and were about to go home. Both of these died suddenly from coronary thrombosis.

These occurrences make us wonder if we can put our finger on the cause and again lower mortality by its prevention. We are getting our patients out of bed earlier, sometimes as early as the first day. This will be greatly important in the prevention of thrombosis. It may be noted that much importance has been placed on water balance in preoperative and postoperative care. In the past after the patient was taking increased amounts of fluids by mouth, we rested on our oars and did not realize that again the patient became dehydrated, leading to increased concentration and viscosity of the blood. Repeated hematocrit readings should be done and dehydration prevented. We now use glucose and blood much longer in the postoperative course than previously and believe we will be rewarded by a lower incidence of heart and blood vessel thrombosis and embolism. We have not been

using the anticoagulants except after thrombosis; perhaps we should.

When we are given some warning, such as deep-seated pain in the leg, we may fear embolism. Daily examination for this and Homan's sign should be tested for. Whether we should rush in and ligate the femoral vein when this sign is positive is a moot question. It has been our experience that deaths usually occur from unheralded massive emboli.

When thrombophlebitis and phlebotrombosis occur, we have had most gratifying results following the use of heparin, dicumeral and penicillin. Our results by conservative methods are so gratifying that immediate surgery in all cases seems too radical a procedure.

#### SUMMARY

The author has performed 600 partial gastrectomies. A high mortality in the earlier cases has now been reduced to 2.5 per cent. As many as sixty consecutive gastrectomies have been performed with no mortality. Close attention to preoperative preparation is essential. A well planned, simplified operation has been described. This allows rapidity and reduces shock. A transverse incision is urged to prevent evisceration and to give good exposure.

The author wishes to emphasize the early recognition and treatment of lung complications, embolism and coronary thrombosis. These are also discussed and suggestions made for their reduction.

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A. D. OCHKIN of Russia followed up 102 cases of gastrointestinal cancer and summarizes his findings and recommendations: For cancer of the stomach a palliative gastrojejunostomy or a simple jejunostomy for feeding purposes seems well worth while. Patients were made more comfortable and lived an average of two months to four months longer. Radiotherapy may be attempted as a supplementary measure but one must not expect many of these growths to be radiosensitive. Life is often prolonged considerably by palliative surgery and a fixed growth, formerly considered inoperable, often becomes smaller and mobile so that surgery, later, becomes possible. For all of these reasons the author believes that palliative surgery for advanced cases of cancer in the gastrointestinal tract as well as in the head of the pancreas are well worth doing. (*Richard A. Leonardo, M.D.*)

## GASTROJEJUNOCOLIC FISTULA\*

ARKELL M. VAUGHN, M.D., L. C. HOLLISTER, M.D. AND F. A. LAGORIO, JR., M.D.  
Chicago, Illinois

A GASTROJEJUNOCOLIC fistula is an abnormal opening connecting the stomach, jejunum and colon, thus allowing ingested food to pass directly from the stomach into the colon, and in turn also allowing fecal contamination of the stomach and small bowel. The irritating presence of feces in the upper gastrointestinal tract produces a vicious diarrhea which leads to dehydration, anemia and further impairment of digestion and absorption. This condition may be seen as a complication of gastric cancer or more rarely as a complication of chronic ulcerative colitis.<sup>1</sup>

*Etiology.* Glickman<sup>2</sup> has stated that the causes of gastrocolic fistulas before the widespread use of gastro-enterostomy were, in order of frequency: cancer, ulcer, abscess in the peritoneal cavity, tuberculosis and congenital anomaly. Bornstein and Weinshel<sup>3</sup> present a very inclusive list of secondary and precipitating factors, stating that a gastrojejunal ulcer, and primarily a duodenal ulcer, is responsible for the formation of a gastrojejunocolic fistula, and that factors precipitating the marginal ulcer are (1) focal infection, trauma, tuberculosis or syphilis; (2) marked hyperacidity, inasmuch as the jejunum which is accustomed to an alkaline medium is now exposed to an acid one, as shown by the experiments of Mann and Williamson;<sup>4</sup> (3) operative trauma to the mucosa from the improper use of clamps; (4) use of non-absorbable sutures and Murphy buttons; (5) foreign body inclusions; (6) indiscretion in diet too soon after surgery; (7) carelessness in medical supervision; (8) excessive smoking, alcoholism and use of condiments; (9) fatigue or exposure; (10) arterio-

sclerosis; (11) resolution of hematomas; (12) faulty surgical technic, e.g., placing the anastomosis too high, and (13) the same causes which produced the original ulcer.

*Pathology.* A gastrojejunocolic fistula usually connects the jejunum with the transverse colon; rarely does the stomach connect directly with the colon. The fistula is usually existent close to the anastomosis and generally inferior to it and is located on the distal loop of the jejunum. The fistulous tract is lined with smooth, glistening mucous membrane, while the mucosa of the surrounding tissue (gastric, jejunal and colonic) may show evidence of marked inflammation.

*Symptomatology.* The outstanding symptom of a gastrojejunocolic fistula is diarrhea. The stool is watery, semisolid, fatty and generally contains many undigested food particles. It has a pungent, foul odor and fails to respond to the usual medical treatment. It is acid in reaction due to the admixture of gastric secretions. Pfeiffer<sup>5</sup> attributes the diarrhea and chemical imbalance in these cases to the regurgitation of colonic material into the upper gastrointestinal tract causing rapid peristalsis throughout the small intestine with little or no absorption of food.

There is marked emaciation, weakness and dehydration if the condition has existed for any length of time. Eructation of a stercorous smelling gas is another of the more aggravating symptoms, and the administration of enemas will increase the frequency and degree of this condition. Vomiting is frequently present and is usually fecal in nature. This is increased by large enemas and decreased by frequent

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gastric lavage and administration of a constipating diet. In the absence of intestinal obstruction, Bornstein and Weinshel<sup>3</sup> believe that fecal vomiting is pathognomonic of gastrojejunocolic fistula. There is always weight loss which is generally marked and rapid in onset. Anorexia is usual although occasionally there is an unimpaired or increased appetite and intake of food. Abdominal pain to the left and below the umbilicus may or may not be present and, if present, may cease after the formation of the fistula. The patient generally shows some degree of anemia which is generally due to the failure to absorb iron or else the inability to absorb the anti-anemic factor of Castle. Atwater, Butt and Priestley<sup>6</sup> found in reviewing their series of thirty-nine cases that 14 per cent of these patients showed a macrocytic type of anemia. Hemorrhage may be present during the existence of the marginal ulcer and persists following the formation of the fistulous tract. A low serum protein is generally present in patients who have suffered for some time with the disease and may be manifested by a nutritional edema.

**Diagnosis.** The diagnosis of this condition is based upon a history of previous peptic ulcer which had been treated surgically by gastro-enterostomy which had afforded temporary relief. This is followed by a period of abdominal discomfort or pain, nausea, vomiting or hemorrhage which in turn is followed by diarrhea, stercorous eructation, weight loss and cachexia.

Physical examination of the patient may prove negative except for malnutrition, apparent anemia and the presence of an abdominal scar. A mass is seldom felt and, if present, is due to adhesions or a regional inflammation. Examination of the stool may reveal blood, occult or fresh, and may also reveal many undigested food particles. The employment of dyes either rectally or orally, and their recovery by gastric lavage or enema, may be helpful in the determination of the presence of a fistula. Roentgenologic examination with barium medium

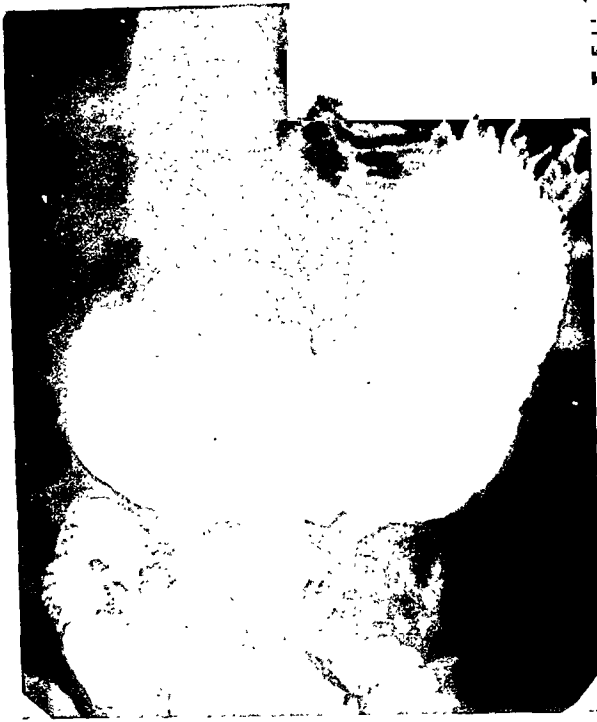
showing direct passage between the stomach, jejunum and colon establishes the diagnosis with a certainty. However, both a barium meal and enema should be employed.

**Prognosis and Mortality.** The prognosis of a patient suffering from a gastrojejunocolic fistula must always be considered grave and, without surgical intervention, the course is one of continued malnutrition and emaciation which usually results fatally. The operative mortality varies considerably. Marshall<sup>7</sup> reports an operative mortality of 7.1 per cent occurring in the surgical treatment of fourteen patients. Pfeiffer<sup>5</sup> reports a mortality of 6.6 per cent; Ransom<sup>8</sup> 14 per cent; while other reports in the literature show varying percentages up to 63 per cent.

**Treatment.** The treatment of these patients is primarily surgical but the pre-operative care necessary to bring them up to a somewhat normal level is most adequately handled as reported by Gray and Sharpe.<sup>9</sup> Many different surgical technics have been employed in the treatment of this condition, and the method of choice seems to be that which is applicable to the pathological condition found at operation.

Evans and Skinner<sup>10</sup> state that in instances of extensive induration and adhesion formation, resection *en bloc* may be the only procedure. Findlay<sup>11</sup> has advocated using the Mikulicz procedure in a multiple-stage operation exteriorizing the colon and attached jejunal stump. Finsterer<sup>12</sup> preferred a one-stage operation but states that a two-stage operation is indicated in those individuals in whom a simple closure of the fistula is impossible because of its size. Pfeiffer<sup>13</sup> advises a preliminary proximal loop colostomy with jejunostomy.

Lahey and Swinton<sup>14</sup> and also Marshall<sup>7</sup> advocate a technic whereby the terminal ileum as a preliminary measure is cut across, the distal end closed and the proximal end anastomosed to the descending colon as a first-stage procedure. Then at the end of two weeks the ascending colon,



1



2

FIGS. 1 and 2. Case 1. Roentgenograms taken January 8, 1945, before surgery. In Figure 1 barium meal reveals gastro-enterostomy and defect of cap. Figure 2 is a roentgenogram taken five hours after barium meal. Note (1) barium in stomach; (2) barium in transverse colon; (3) barium in distal ileum; (4) absence of barium in cecum and ascending colon.

the remaining terminal ileum, the fistula, the jejunum and the portion of the stomach to be resected are removed *en bloc*, and the end of the transverse colon distal to the fistula closed, with the fecal stream already diverted and established. The jejunum is reunited by an end-to-end anastomosis and then anastomosed to the resected stomach.

#### CASE REPORTS

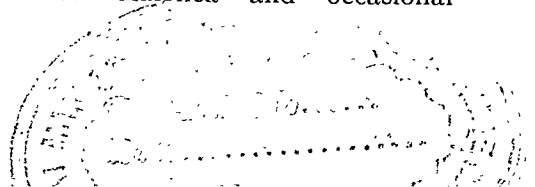
**CASE 1.** Mr. W. C. entered Mercy Hospital February 10, 1945. His chief complaint was epigastric pain, radiating to the back, coming on two to three hours after eating and relieved by vomiting, ingestion of food or alkalies, which had been present for the past twenty years, during which time he had been on peptic ulcer management by Sippy powders and diet. Early in 1938 he developed symptoms of obstruction. He would generally vomit after the second meal of the day and the vomitus would consist of undigested food. No blood was ever noted. His diet was changed to softer foods and soon only liquids were tolerated. This relieved the patient of vomiting to some degree but he suffered a weight loss of 40 pounds over

a six months' period. In March 1938 the patient underwent surgery and a posterior gastro-enterostomy was performed. He did fairly well on a modified diet for the ensuing year.

In March 1939 he had an attack of severe pain generalized throughout the abdomen with greater intensity in the right upper quadrant. The right side of the abdomen was exquisitely tender but there was no radiation to the right shoulder. Treatment was symptomatic with five weeks of bed-rest. His symptoms gradually subsided. He gained in general health and weight although still experiencing attacks of vomiting.

General good health was maintained until November, 1944, when he began to notice an increasing amount of fatigue, more frequent attacks of vomiting and a progressive weight loss, totaling 30 pounds over a three months' period. The month preceding admission to the hospital he noticed that food recently eaten would be passed in the bowel movement in a short time practically unchanged. During this time he had an insatiable appetite and thirst, but experienced diarrhea and occasional vomiting.

July, 1949





The x-ray examination revealed (Fig. 1) filling of stomach with passage of barium through old gastroenterostomy into jejunum but also passage of barium into large bowel. A barium enema (Fig. 2) showed filling of large

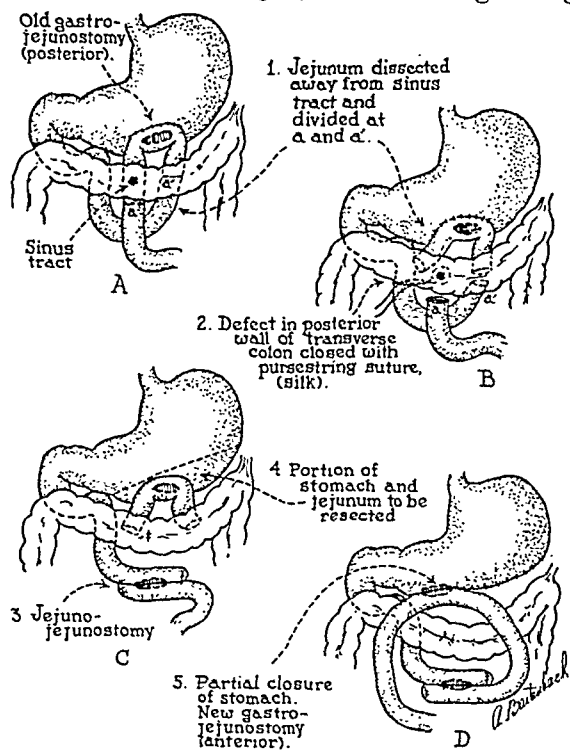


FIG. 3. Case 1. Diagrammatic sketches A, B, C and D showing steps in the repair of a gastrojejuncolic fistula. A modified Lahey anterior gastro-enterostomy is shown. A gastric resection instead of the gastro-enterostomy is usually the procedure of choice.

bowel with passage of barium into stomach and small bowel.

The conclusion arrived at was gastro-enterocolic fistula.

The laboratory work-up revealed no apparent anemia due to dehydration; serum protein 4.42. Preoperatively the patient was placed on sulfasuxadine, high caloric diet, multi-vitamins and blood and protein replacement therapy.

On February 19, 1945, under spinal anesthesia the patient underwent surgery for repair of the gastro-enterocolic fistula. The following steps were done: (1) Closure of the fistula in the transverse colon by a purse-string silk suture, superimposed by interrupted silk mattress sutures (Fig. 3B); (2) resection of the jejunum proximal and distal to the fistula with a lateral anastomosis of the remaining jejunum (Fig. 3C); (3) resection of a portion of the greater curvature of the stomach with the

former gastro-enterostomy stoma and attached jejunal segment, including jejunal ulcer (Fig. 3C); (4) anterior gastro-enterostomy of jejunum distal to site of lateral anastomosis, and to distal end of greater curvature of the stomach—Lahey anterior gastro-enterostomy. (Fig. 3D.)

His postoperative course was not remarkable and he was discharged on the twenty-first postoperative day.

X-rays taken six months postoperatively revealed (1) after a barium enema (Fig. 4) a normal large bowel; after a barium meal (Fig. 5) a functioning gastro-enterostomy. The laboratory findings eight months postoperatively showed red blood count 4,390,000, hemoglobin 12.3 Gm., serum protein 6.0. Gastric analysis one year postoperatively showed free hydrochloric acid 28°, total acid 36°; no blood present.

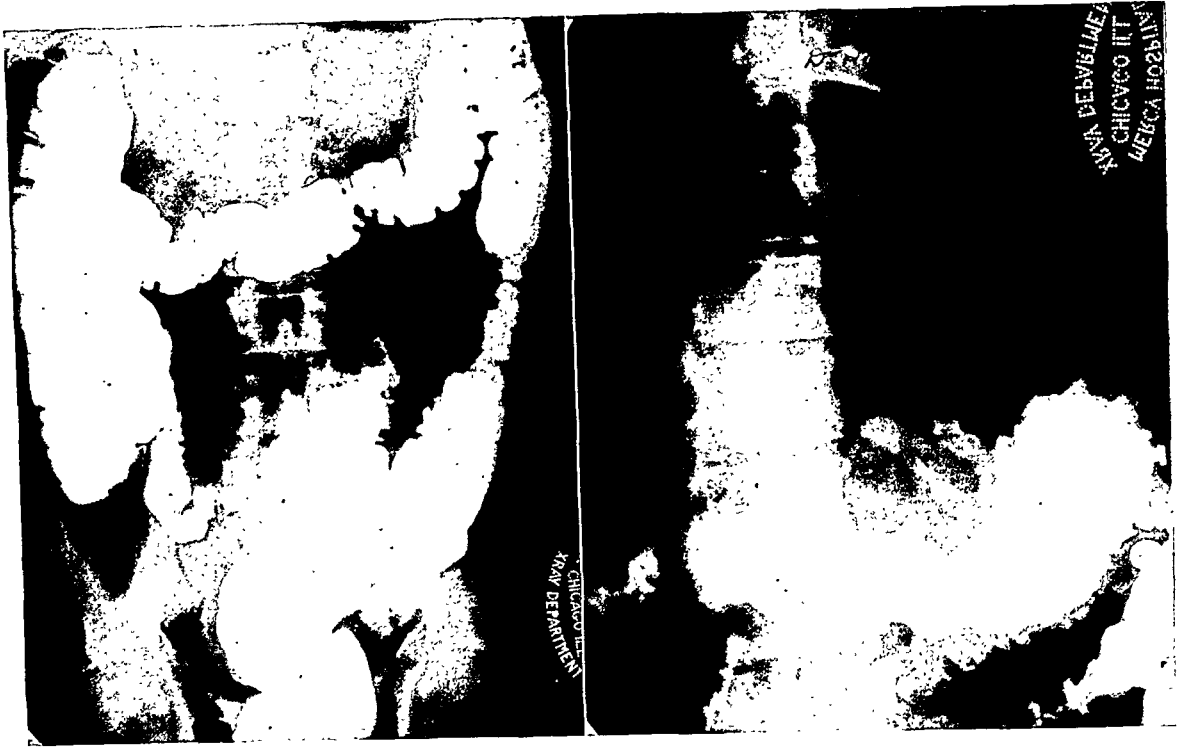
At the present time he weighs 185 pounds while weighing only 130 pounds at the time of surgery. He is now working daily at his trade.

CASE II. Mr. R. B., aged forty, entered Mercy Hospital on December 3, 1946, complaining of nausea, vomiting, diarrhea, weight loss and generalized colicky abdominal pains which had been present for the past year. The following past history was obtained:

In August, 1940, the patient was operated upon and hospitalized for twenty-one days in a Chicago hospital with a diagnosis of a ruptured peptic ulcer. His postoperative course was uneventful except that following his release from the hospital he was unable to tolerate food and had a feeling of epigastric fulness.

In May, 1941, he suffered a second perforation of a peptic ulcer and following celiotomy was informed that, besides the ruptured ulcer, he also had a "bowel obstruction" and that a posterior gastro-enterostomy had been done. His postoperative course was uneventful except that his wound failed to heal, and he was discharged from the hospital twenty-eight days later with an open skin wound which healed three months following discharge. Subsequently an incisional hernia had developed. This hernia was repaired in November, 1943, and he returned to work as an electrician six months later.

While at work in the summer of 1944, he was accidentally struck in the abdomen by a wrench. This was followed by sharp, colicky pains in the upper abdomen, associated with nausea. He was also aware of a swelling in the



FIGS. 4 and 5. Case I. Roentgenograms taken October 8, 1945, after surgery. In Figure 4 note that there is no reflux into stomach and normal lumen of bowel on barium enema study. Figure 5 shows diminished size of stomach and new gastro-enterostomy.



FIGS. 6 and 7. Case II. Photographs taken at time of operation; Figure 6 shows relations of transverse colon (which is retracted upward), stomach and jejunum. Note absence of adhesions or inflammatory reaction. Figure 7 reveals relations of transverse colon (which is retracted downward), stomach and jejunum.

region of his incision and was again hospitalized and a large abscess was drained. He was discharged in nine days but a purulent drainage continued for the next year. The patient returned to work six months following incision and drainage of the abscess, but he now complained of fatigue and night sweats.

had spontaneous attacks of vomiting and stated that the vomitus looked, smelled and tasted like feces. He had been having four to six loose, watery stools daily and at times noticed undigested food particles in his feces. He had lost 20 pounds in weight during the past year; his original weight was 136 and his admission weight was 116 pounds. He stated that his appetite was excellent and he could not understand why he had been unable to gain weight and control the diarrhea.

Laboratory findings on admission revealed red blood cells 4,000,000, hemoglobin 12.59 Gm. (81 per cent), total protein 4.62. Preoperative x-rays were poor due to extreme discomfort of the patient. Preoperative care consisted of a high caloric diet, mult-vitamins, blood and protein replacement therapy.

The operative procedure was performed with fractional spinal anesthesia. A left upper rectus muscle splitting incision was made and the peritoneal cavity found to be free from adhesions. The fistulous tract was easily found and was free of any dense adhesions or inflammatory reactions. (Figs. 6 and 7.) The fistulous tract was of a large diameter. (Fig. 8A and B). Due to the large size of the tract it was obvious that extensive resections had to be employed. The jejunum proximal and distal to the tract was resected and united by lateral anastomosis. (Fig. 8D and E.) The greater curvature of the stomach bearing the fistula and the remnant of the former gastro-enterostomy was then resected. (Fig. 8E.) Following this, the portion of the transverse colon involved in the fistula was also resected and reunited by lateral anastomosis. (Fig. 8C and D.) This was followed by an anterior gastro-enterostomy of the Lahey type, and the portion of the jejunum distal to the site of the previous lateral anastomosis was used for the anastomosis between the jejunum and the greater curvature of the stomach. (Fig. 8F.)

The patient's postoperative course was not remarkable and he left the hospital on the forty-third postoperative day. His stay in the hospital was greatly lengthened by a problem of Social Service disposition since he was unemployed.

Postoperative x-rays showed the following: After a barium meal (Fig. 9) a functioning gastro-enterostomy; after a barium enema a normal appearing colon with evidence of anastomosis in the transverse colon.

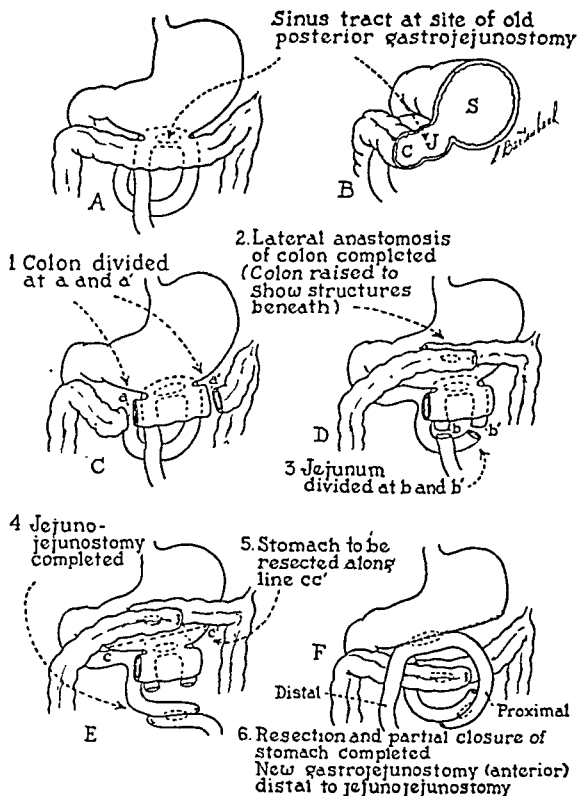


FIG. 8. Case II. Diagrammatic sketches A, B, C, D, E and F showing steps in the repair of a gastrojejunocolic fistula. A modified Lahey anterior gastro-enterostomy is shown. End-to-end anastomosis of the transverse colon and of the jejunum is quicker but it is a matter of opinion as to whether end-to-end or lateral anastomosis should be used.

In November, 1945, he had a sudden onset of epigastric pain accompanied by nausea, vomiting and diarrhea. His stools at this time were at first tinged with bright red blood and later became tar-colored. He was again hospitalized for twenty-eight days during which time he was placed on Lextron and a bland diet. Upon discharge he was without symptoms.

In March, 1946, the patient suffered another remission with nausea, vomiting and bloody diarrhea. Since that time he had frequent attacks of nausea and belching which he described as fecal smelling and tasting. He also

At the time of discharge his weight was 135 pounds while at the time of surgery it was 115 pounds.

#### COMMENTS

The management of gastrojejunocolic fistula is one of surgical necessity, but the proper preoperative management of these patients cannot be stressed too greatly. Today with our increased knowledge of nitrogen balance and intravenous corrective therapy, these patients usually can be brought to surgery in optimum condition.

Since the advent of sulfa drugs, penicillin, plasma and extensive employment of whole blood, in addition to improved technic in anesthesia, especially spinal, the operative procedure can usually be performed in one stage.

In the presence of marked inflammation about the site of the disorder, we can readily understand the value of a preliminary colostomy as advocated by Pfeiffer and Kent.<sup>13</sup>

Resection of the fistula *en bloc* followed by a subtotal gastric resection and re-establishment of the gastrointestinal continuity is the procedure of choice. This procedure should reduce the gastric acidity sufficiently to prevent the recurrence of a marginal ulcer.

Since the operation is one of great magnitude, usually requiring several hours and associated with a high operative mortality, an anterior Lahey type of gastro-enterostomy can be used to re-establish the gastrointestinal continuity, lessen the operative time and thus lower the mortality. For the above mentioned reasons this procedure was carried out in the two cases herein reported. In the patient of older age with a low gastric acidity the possibility of a future recurrence of a marginal ulcer must be weighed against the possibility of an operative mortality. We chose the first alternative, fully realizing that a subtotal gastrectomy was theoretically the operation of choice. Likewise, our choice in the use of a lateral anastomosis

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FIG. 9. Case 11. Roentgenogram taken five hours after the meal shows small amount of barium still in the stomach and duodenal cap. The remainder of meal is irregularly scattered throughout the small bowel and colon. The bowel shows typical cobblestone appearance of vitamin deficiency; x-ray also shows a functioning gastro-enterostomy.

was one of confidence in personal surgical technic.

Recently in view of the work done by Dragstedt<sup>15</sup> and his associates upon the effects of the vagus nerves on gastric secretion, motility and acidity, we believe that another beneficial procedure has been placed in the hands of the surgeons for the treatment of marginal ulcers and for the prophylaxis of gastrointestinal ulceration by means of section of the vagus nerves. Since the patient in Case 11 had experienced two previous peptic ulcer perforations and developed a jejunal ulcer with resultant perforation into the transverse colon, we believe that he is a candidate for future gastrointestinal ulceration and should be followed very closely. In the event that such a condition arises, we are of the opinion that supradiaphragmatic section of the vague nerves is the procedure of choice; and the patient, being well aware of his ulcer tendency, has already agreed to

this procedure if at any time we think it advisable. However, two and one-half years have elapsed without further symptoms and the gastric acidity is still within normal range.

### CONCLUSIONS

1. Two successful one-stage operations for gastrojejunocolic fistula are reported.
2. A partial review of the literature is presented.
3. Improved methods of anesthesia are an aid in permitting this operation to be done in one stage.
4. Pre- and postoperative care is directed toward the correction of imbalanced physiology.
5. The Lahey anterior gastro-enterostomy was used successfully in both cases.
6. A macrocytic type of anemia was not present in either case.
7. Both cases occurred in males whose average age was forty-four years.
8. The marginal ulcer, with subsequent fistula formation, followed previous posterior gastro-enterostomies.
9. In Case 1 the fistula developed six and one-half years following formation of the marginal ulcer, while in Case 11 the time interval was four months.
10. Four years and two and one-half years, respectively, have elapsed since surgery with no recurrence of symptoms.

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# Case Reports

## CYSTADENOMA OF THE PANCREAS

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**T**RUE cysts of the pancreas, while rare enough to stimulate our enthusiasm for accurate diagnosis and to

her general health had always been good. There were no urinary symptoms or loss of weight. There was no history of trauma or of any para-

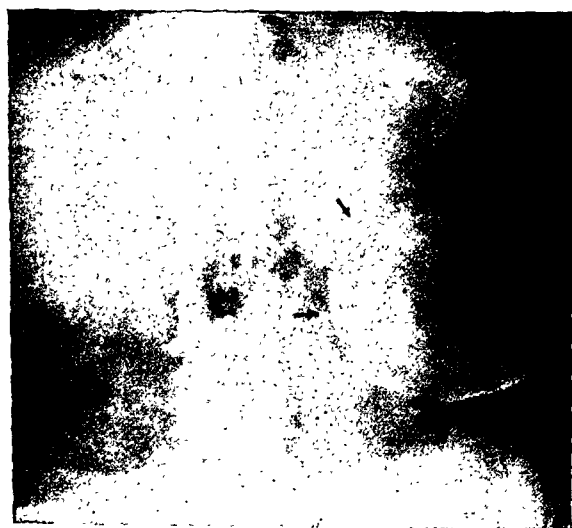


FIG. 1. Case 1. Flat plate demonstrating calcified pancreatic cystadenoma.

arouse our interest in the most proficient manner of treatment, are more common than a perusal of the literature would lead one to believe.

True cystadenomas, springing from the tail of the pancreas, were diagnosed preoperatively in both cases reported herein. Both cystadenomas gave surprisingly little discomfort or symptoms and both were amenable to complete extirpation.

### CASE REPORTS

**CASE 1.** L. D'A., Case No. 168047, fifty-four years of age, was admitted to the Jewish Hospital on October 21, 1940, complaining of pain in the epigastrium. For several months preceding admission she had a "feeling of fullness" in the upper left quadrant of the abdomen. She had not vomited. Her bowel habits were regular;

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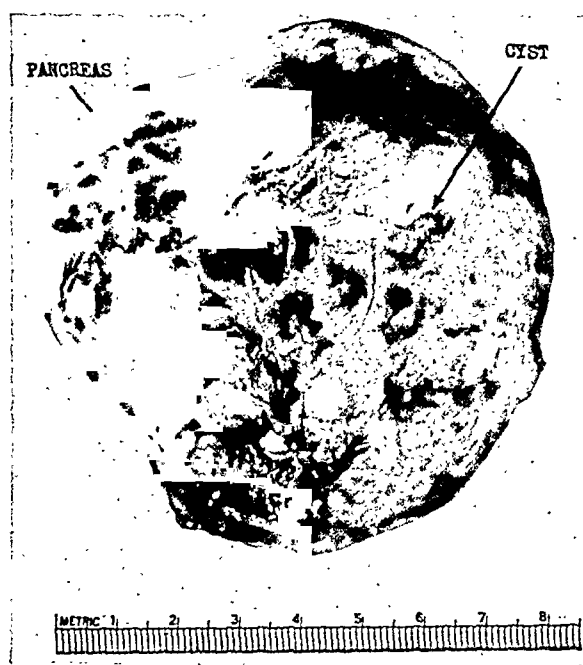


FIG. 2. Case 1. Photograph of specimen removed from patient.

sitic infection. Physical examination was essentially negative except for the presence of a smooth, rounded mass the size of an orange in the upper left quadrant of the abdomen. The mass was not mobile from side-to-side but moved up and down with respiration. The fasting blood sugar ranged from 90 to 130 mg. per 100 cc. The blood urea nitrogen was 15.5 mg. per 100 cc. Blood amylase calculation was not done. The flat plate x-ray (Fig. 1) showed a large calcified cyst. The preoperative diagnosis was cyst at the tail of the pancreas.

Operation was performed on October 22, 1940, under spinal anesthesia. An upper left rectus incision was made. The tumor mass was most prominent between the stomach and

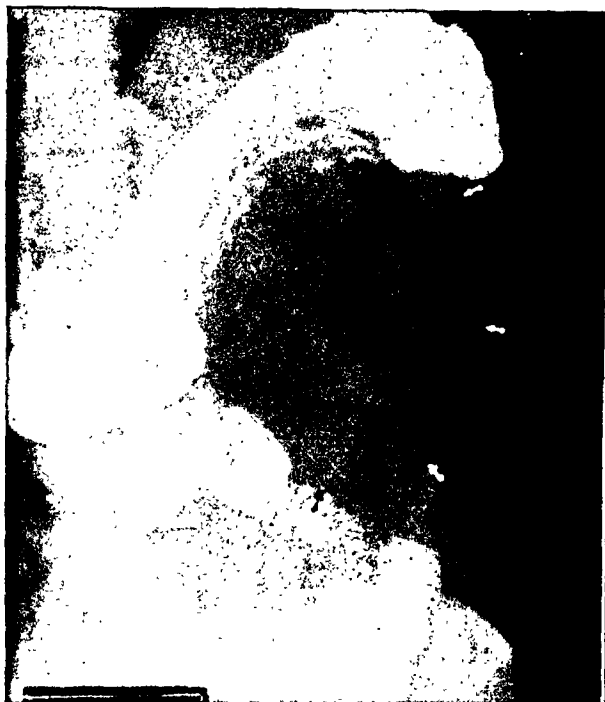


FIG. 3

FIG. 3. Case 11. X-ray showing typical pressure deformity of the stomach.



FIG. 4

FIG. 4. Case 11. X-ray showing displacement of the stomach upward and the transverse colon downward.

transverse colon. Accordingly, the gastric colic omentum was opened in an avascular area, the colon being mobilized downward and the cyst exposed. Extirpation was decided upon as the method of choice and was accomplished by sharp dissection until a plane of cleavage was obtained. It was easy to enucleate the cyst by blunt dissection with the finger down to its rather broad base in the tail of the pancreas. A small piece of the pancreas was excised with the cyst. (Fig. 2.) The wound in the pancreas was closed with interrupted sutures of linen thread. The rent in the mesocolon was closed and the abdomen was closed without drainage.

The patient made an uneventful recovery and was discharged from the hospital on the eleventh postoperative day. Follow-up information was obtained from her family physician who reported her well and symptom-free one, three and five years after operation.

The specimen consisted of a portion of pancreas measuring  $1\frac{1}{2}$  cm. in length and a pancreatic cyst measuring  $8\frac{1}{2}$  cm. in diameter. The surface was irregular and hard in consistency. On cross section it consisted of a unilocular cyst the lining of which was thin and calcified and filled with amorphous, chocolate material. Section of tissue showed a large number of acini and pancreatic tissue lined by

cuboidal cells arranged in cluster formation. The nuclei resulted on a basement membrane. There was pronounced hyperplasia of the islands of Langerhans. There was a numerical increase in the number of islands as well as an increase in the size of individual islands. There was no evidence of malignancy. The diagnosis was cystadenoma of the pancreas.

CASE 11. M. W., Case No. 5263, thirty-six years of age, was referred to our service at St. Joseph's Hospital on December 15, 1946, complaining of cramp-like pains and a sense of fullness in the upper left quadrant of the abdomen. For the past year she had had pains after eating. There was no history of vomiting or change of bowel habits and no urinary symptoms. She had lost 10 pounds in the past year but this may have been by purposeful dieting. She had two children. Menstruation was regular. There was no history of abdominal trauma and physical examination was essentially negative except for the abdominal portion. Filling the entire upper left quadrant was a large, smooth, rounded mass, the size of a basketball. The spleen could not be palpated separately. The mass was fixed; it could not be moved from side-to-side and did not move with respiration. Vaginal examination was negative. X-ray studies before admission to the hospital showed the presence

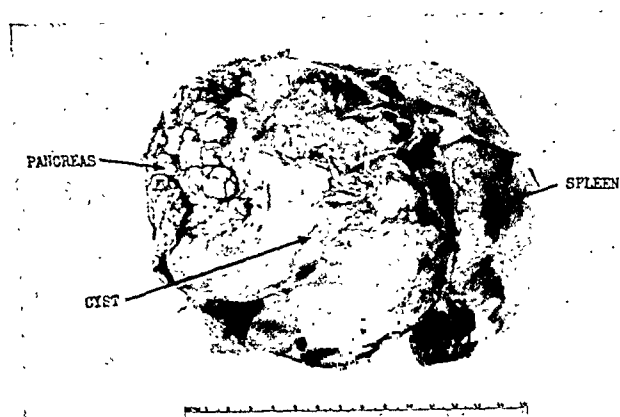


FIG. 5

FIG. 5. Case 11. Photograph showing specimen of the cyst with spleen attached and portion of the pancreas.



FIG. 6

FIG. 6. The same as Figure 5 showing the cyst opened.

of a tumor between the stomach and colon. (Figs. 3 and 4.) On admission the patient's blood count was within normal limits, blood sugar 123 mg. per 100 cc. and blood urea 9.6 mg. per 100 cc. The laboratory reported a blood amylase of 1,600 units. (The figure is so high that we question the accuracy of this determination.)

Operation was performed on December 18, 1946, under fractional spinal anesthesia. The abdomen was opened by an upper left rectus incision. An enormous cyst, springing from the pancreas, was between the stomach and transverse colon. For complete extirpation more room was needed than could be obtained through the gastrocolic omentum. Consequently, an indirect approach was made by turning the transverse colon and great omentum upward and opening the transverse mesocolon in an avascular area, with due regard for the middle colic artery. With great difficulty, a plane of cleavage was found after careful separation of the adhesions. Once the correct plane of cleavage was established it was easy to enucleate the cyst by blunt dissection with a finger and occasional sharp knife dissection. The splenic artery and vein were so incorporated in the cyst wall that we decided to remove the spleen with the cyst. Apparently the spleen had not been functioning properly for some time due to pressure on its vessels. This is assumed because we noted and carefully left four accessory spleens about the size of large cherries. Hemostasis was troublesome. Oozing from the cyst bed was controlled by

gelofoam gauze. The rent in the mesocolon was closed around a small, soft rubber drain.

Convalescence was entirely uneventful. The patient was out of bed the following day and left the hospital on the tenth postoperative day. Four months after operation her family physician reported that she was entirely well and symptom-free except for hepatitis with jaundice which occurred two months after operation and lasted two weeks. This we attribute to the plasma or blood which she received during the operation.

The specimen (Figs. 5 and 6) consisted of the spleen measuring 14 by 6 by 6 cm. with a large cyst measuring 14 cm. in diameter intimately attached throughout its length. The cyst wall was 2 to 4 cm. thick. It was fibrous, multiloculated and contained chocolate-colored mucus-like material. Sections of the cyst wall showed characteristic epithelium with a single row of tall columnar cells with basely situated nuclei. In some regions the epithelium was papillary in formation but nowhere was there more than one layer of cells seen. The underlying subepithelial tissue was fibrous. The diagnosis was benign multiloculated papillary cystadenoma.

Pascucci<sup>1</sup> gives the incidence of pancreatic cysts as 0.061 per cent. Brunschwig differentiates between true cysts and cystadenomas. He states that the latter are more solid in consistency without free communication between the loculations of the cyst and that they rest in the pancre-



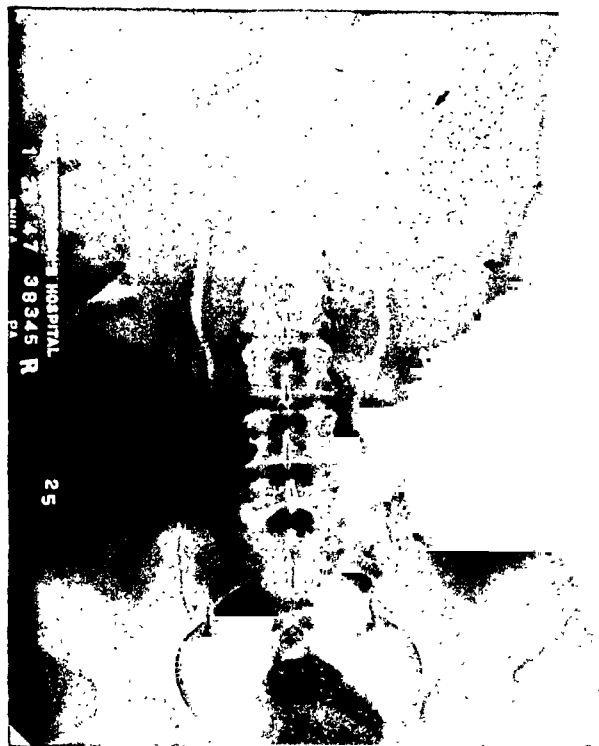


FIG. 7

FIG. 7. Intravenous urography showing normal kidney outline and large cyst, filling the left hypochondrium.



FIG. 8

FIG. 8. X-ray, same case as Figure 7, showing typical gastric deformity and displacement of the intestine to the right.

atic bed rather than protrude from it by a pedicle. It seems to us that the final decision must rest with the pathologist and must be based on his microscopy of the cyst wall. We conceive that the consistency and intercommunication of the multilocular cyst is merely a progressive picture of pressure, hemorrhage and breakdown of its contents.

Attempts at calcification of true cysts of the pancreas have been made by almost all authors. Pascucci, Thigpen, Kaufman, Johnson,<sup>2</sup> Pinkhan and others each has his own differentiation. It is of little moment except to separate the so-called pseudocysts which are not cysts at all but collections of old inflammatory processes. True cysts which constitute a distinct clinical entity are either neoplastic in origin or retention cysts. A congenital cyst, for example, could be of either variety but should not be considered as a separate entity. To be unnecessarily precise regarding their classification is unproductive and foolish.

Judd, Mattson and Mahorner<sup>3</sup> and many others have laid stress by diagram and description on the location of the cysts describing them as between the stomach and the colon, beneath the liver, beneath the colon, etc. We contend this is as antiquated as a discussion of the coverings of a hernia. It is obvious that a cyst in its growth and development takes the line of least resistance. It is unimportant where it becomes most superficial. In its removal access to it will be obtained in the most convenient, safe approach that affords the most ease of manipulation.

#### SYMPTOMS

Symptoms produced by pancreatic cysts are symptoms of pressure. No signs or symptoms are peculiar to the lesions. Walter and Cleveland<sup>4</sup> state that 95 per cent of their patients had pain. Most writers mention such symptoms as cachectic state, loss of appetite and weight loss. These result from pressure on the stomach. In like manner, constipation results from

pressure on the colon. Glycosuria and steatorrhea, depending on pancreatic deficiency, are always alluded to at this time. Their presence would indicate either destruction of a goodly amount of the pancreas or interference with its function. In the two cases reported herein both patients had only one prominent symptom in the presence of major lesions, namely, a "sense of fullness" in the upper abdomen. Physical examination revealed an obvious mass in the upper left quadrant.

The differential diagnosis must be contemplated for malignant tumors, aneurysms, retroperitoneal growths, gallbladder disorders with distention and, most particularly, renal cysts or neoplasms and splenomegalies. X-ray examinations should include complete gastrointestinal study including barium enemas and intravenous urography.<sup>5</sup> Figure 7 shows an intravenous urography study with a normal kidney outline overlapped by, but differentiated from, the cyst. It is unbelievable how large a growth may be symptom-free. Figures 7 and 8 show the x-ray findings in M. L., Case No. 282, sixty-five years of age, whom we saw in consultation in January, 1947, at St. Joseph's Hospital. He had a cystic mass the size and shape of a football which extended from the ribs to the umbilicus on the left side of the abdomen. From physical examination and x-ray findings we were convinced that he had a large pancreatic cyst but the patient felt so well that both he and his physician refused operation.

It is surprising how little has been added to our store of knowledge concerning pancreatic cysts in the past twenty years. Moynihan<sup>6</sup> wrote a masterful chapter on pancreatic cysts, and Brunschwig<sup>7</sup> wrote an equally enlightening monograph. However, excluding the advances in surgical technic, practically nothing has been added in the intervening sixteen years.

#### TREATMENT

Once the abdomen is opened and the lesion is identified, three procedures are

available: internal drainage, marsupialization or extirpation. No one will deny that the theoretic method of choice is excision. Internal drainage,<sup>8-12</sup> while ingenious, is not physiologic and at times has proved completely unsatisfactory. Marsupialization with obliteration of the sac by packing has been reported as good in the literature. Judd and others report excellent results. We have had no experience with this procedure but have observed several cases in the hands of our colleagues, with unhappy results. Brunschwig, in speaking of the indications for excision, states that the tumor must not be of excessive size, should be fairly mobile and free of numerous and dense adhesions. We challenge this dictum because had we followed it, neither patient would have been considered for excision. With a careful, deliberate, anatomic approach, anticipating essential structures and vessels and guarding against their injury, a plane of cleavage should be sought. Once this is established a cyst which seems to have insurmountable obstacles to its removal can be shelled out with ease. An attempt should be made to remove the lesion in every case. No harm will be done if due care is taken. If removal is impossible, one of the less advantageous methods can be used to terminate the operation. The absorbable hemostatic gauze was most helpful to us and its use should be borne in mind.

We believe that in dealing with this condition most of us are only "occasional operators" and hesitate to report on our meager experience. This causes true pancreatic cysts to appear to be less common than is actually the case. In like manner, only the more favorable results from the larger and better clinics appear in the literature.

#### CONCLUSIONS

1. True pancreatic cysts, while rare, are more common than the literature indicates.
2. Too much emphasis has been placed on impractical classifications.

3. Cases are presented to show the simplicity of diagnosis with roentgenologic aid.

4. In the light of improved surgical technic and anesthesia a plea is made for removal of the cyst rather than exteriorization or internal drainage.

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PAXTON and Payne studied the records of over 300 patients with acute pancreatitis and found that the patients operated upon had a mortality of about 45 per cent, whereas it was less than half as high for the patients treated medically. If the diagnosis is definite, I am sure the average surgeon also prefers conservative treatment. The authors stress the importance of blood amylase and urinary diastase tests and recommend that both be done simultaneously in questionable cases. (*Richard A. Leonardo, M.D.*)

# MISTAKES IN THE DIAGNOSIS OF CANCER

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THE diagnosis of cancer as the disease manifests its protean characteristics in all body organs is subject to many pitfalls. Many diseases and pathologic conditions mimic cancer in all its stages. All hospitals and institutions devoted to the treatment of cancer have this problem ever before them, i.e., the patient who does not have cancer but an entirely different disease which mimics cancer sufficiently to cause diagnostic confusion and error.

We report herewith a series of twelve cases illustrating mistaken diagnosis in cancer. All of these patients were referred to a hospital service for cancer with the diagnosis of carcinoma, most of them for terminal and nursing care.

The series is presented to call attention to the fact that in all stages of the disease, the thought must be borne in mind that perhaps the patient may not have cancer, and that all events in the clinical course must be scrutinized and all pertinent facts established beyond doubt.

## CASE REPORTS

CASE I. E. C., vesico vaginal fistula (traumatic) diagnosed as cancer of the bladder: The patient, age sixty, was admitted in July, 1943. A letter from a doctor stated that she had been operated upon in November, 1941, (two years before) for a prolapse of the uterus. A subtotal hysterectomy had been done and the pathologic report had revealed carcinoma of the uterus. Following the operation she developed a vesicovaginal fistula. An attempt had been made to repair this on June 20, 1942, and "biopsy at this time showed cancer of the bladder." Another operation for the closure had been done in September, 1942, with poor results.

Examination on admission revealed a chronically ill patient with evidence of recent weight loss. Local examination disclosed edema of the vulva and leukoplakia of both labia. There

were extensive multiple ulcerations of the right labia extending to the crease of the groin. The vagina was smooth and the cervix was clean. There was a rather large 1 cm. puckered fistulous opening in the mid-anterior wall of the vagina which entered directly into the bladder.

Under careful local treatment, including soaks, sitz baths, etc., the ulcerations of the vagina and labia gradually improved. Repeated biopsies of the edge of the ulcer did not show cancer. After much consideration and review of the history it was thought that the bladder fistula might be traumatic in origin, especially since no evidence of carcinoma had been found. Accordingly, it was decided to attempt to close the fistula again.

This was done September 23, 1943. The anterior wall was widely exposed. The walls of the fistulous opening were refashioned and the bladder wall dissected back underneath the vaginal mucosa. The fistula was closed by a double layer of sutures. There was only moderate tension on the suture line.

Convalescence was uneventful. There was no further leakage. The fistula has remained closed and she has been well since. When last seen January, 1946, she was in excellent condition. There was no sign of a fistula or malignant disease.

CASE II. E. D., encrustation cystitis diagnosed as cancer of the bladder: The patient was admitted July 3, 1945, at the age of sixty-eight. About two months prior to admission the patient began to have pain and burning on urination and oliguria. This was followed by a moderate amount of bleeding on urination. Cystoscopy done before admission was reported to have shown an extensive carcinomatous mass on the left side of the bladder encroaching upon and partially obstructing the left ureter.

Admission examination showed a rather senile individual with some evident emaciation, complaining of severe dysuria. The cystoscopic examination was repeated and "an area of inflammation with edema the size of a quarter

was found extending from the trigone toward the dome on the left side. In one area an ulceration was observed. The lesion seemed more inflammatory than malignant in character but one could not rule out malignancy from its appearance." Following two weeks of bladder irrigations and general therapy, re-examination showed that the mucosa of the bladder had greatly improved. There was some inflammatory edema above the trigone and only a very small ulcerated area to the left. Ureteral orifices now were normal.

The bladder irrigations were continued for a few more weeks. The urine became clear and her pain on urination ceased. Final diagnosis was changed to subacute hemorrhagic ulcerative cystitis. Further follow-up of this case disclosed that the bladder symptoms did not reappear and there was no further dysuria. The patient still continued to complain of general malaise, was forgetful and easily upset emotionally. Evidently these were continuing senile changes. On January 15, 1946 she felt fine and no dysuria was present.

The differentiation between simple ulcerative cystitis and ulceration due to bladder carcinoma is a difficult decision that the urologist is frequently called upon to make. When a negative biopsy is obtained, the encrustations may have to be washed or dissolved out first before one can obtain a satisfactory view. This is not always possible. Clinical observation and treatment of the inflammation is the only way to make the differential diagnosis with reasonable certainty.

CASE III. L. T., bladder calculus and cystitis diagnosed as cancer of the prostate: The patient, age seventy-three, was admitted on September 8, 1945. His complaint has been frequent, painful, scanty urination which started a long while ago, approximately six years as nearly as he remembered. In 1943 he had a transurethral prostatic resection followed by a bilateral orchidectomy for this trouble. The pathologic report was carcinoma of the prostate. He improved following this but remained weak and feeble. For one year prior to admission he had been in a convalescent hospital. In the last three months he had been treated for a urinary infection with sulfadiazine. The diagnosis made by the

referring physician was carcinoma of the prostate, recurrent, with spinal metastasis.

Examination revealed an old, chronically ill man, depressed but cooperative, with some evidence of senility. Locally there was a small anal fistula. The prostate was very small and atrophic as felt per rectum. The testes were absent from the scrotum. X-ray of the pelvis was negative, but a large lamellated calculus was noted in the bladder area on the film. In the hospital he had no specific complaints and required no specific medication although his general condition was not good. About October 24th, five weeks after admission, he started to become mildly irrational, then at intervals talkative, noisy or drowsy. By November 5th his condition was poor and from there on he slowly sank, became comatose and died November 11, 1945. He never got into proper physical condition to warrant cystoscopy or bladder exploration.

Reviewing the history and clinical course of this senile old man, we doubted the diagnosis of carcinoma before death. First, urinary disturbances were present for six years or more, and while this is known in carcinoma of the prostate, it is unusual. The average duration from onset of symptoms to exitus is three and one-half years if uncontrolled. The patient was able to void without urinary obstructive evidences and the prostate was small and smooth per rectum. There were no bony metastases to the pelvis. The lamellated calculus and its large size indicated that the stone had been there for a long time. The symptoms and entire clinical course, we thought, could be satisfactorily explained on the assumption of a bladder calculus with accompanying traumatic cystitis from pressure and friction between it and the bladder mucosa.

Autopsy revealed an emaciated, flabby man. The bladder when opened contained foul-smelling urine. There was an oval calculus 2 by 2 by 4 cm. The mucosa of the bladder was discolored, hemorrhagic and edematous. The prostate was small, partially atrophic, and no gross carcinoma was seen on cut section. Both kidneys were small, about one-half normal size, with granular cortex surface  $\frac{1}{2}$  mm. in thickness and indistinct markings. The medulla was grossly normal. The pelvic lining was slightly thickened but smooth. The remainder of abdominal viscera were normal. Permission was limited to the abdominal cavity. The post-

mortem diagnoses were: calculus in bladder, hemorrhagic cystitis, chronic arterial nephrosclerosis and probable uremia.

CASE IV. C. K., granuloma of the rectum diagnosed as carcinoma of the rectum. The patient, age forty-four, colored, was admitted on February 9, 1944. A note from her referring physician said she had carcinoma of the rectum. Her illness began in 1935 with constipation and drainage of whitish material from the rectum. In 1938 she saw a doctor who told her she had a fistula-in-ano. She was operated on for the same with no improvement. In 1940 she saw another physician and was operated upon again. In 1941 she had diarrhea; in 1942 and 1943 the diarrhea continued. It appeared to improve temporarily but then relapsed. During the past two months she had as many as thirty brown, greenish or whitish movements. They were occasionally streaked with blood and were black and foul-smelling. For the past nine months there had been weakness. There was persistent gaseous distention of the abdomen and she vomited at intervals of about two or three days.

Examination revealed a large colored woman who was slightly anemic. The anus was spastic and tender on entrance of the index finger. The canal was funnel-shaped and the pararectal tissues were rigid. There was no definite cancer seen or felt. The lumen of the bowel for 2 inches above the anus was about the size of a pencil. In other words, there was a long stricture here. X-ray showed alteration of the mucosal markings of the rectum in front of the sacrum and irregular areas of filling. Repeated biopsy revealed smooth muscle infiltrated with leukocytes and small foci of fibrous tissue but no carcinoma. Diagnosis was granuloma of the rectum. The Frei test was done on March 10th and was slightly positive.

*Comment.* The strictures which develop (principally in colored females) after long-standing harboring of the virus of lymphogranuloma inguinale were originally considered luetic, then gonorrheal. They are more apt to be confused with these two venereal infections than with cancer. Nevertheless the hard firm granular stricture which the end result of this disease presents, may easily be confused with cancer.

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Regarding the relationship of these granuloma inguinale rectal strictures to cancer, David and Loring<sup>1</sup> reported three cases in which carcinoma followed long-continued granuloma and cited two other cases from the literature. Barber and Murphy<sup>2</sup> reported that in their series (forty-three cases) 8.6 per cent had associated malignant disease. However, in the discussion of David and Loring's paper Curtis Rosser<sup>3</sup> stated that in over 200 observed cases he "had never detected a squamous cell cancer developing in one of the lesions." Likewise in Singleton's series of 181 cases<sup>4</sup> "not one had developed cancer." Thus this long-standing, chronically infected lesion may metamorphose into cancer as any similar lesion does occasionally. However, the incidence of this change varies among observers: by some, never; others, rarely; still others find that an appreciable incidence of cancer develops.

CASE V. E. B., diverticulitis sigmoid x-ray and o.r. diagnosis given as carcinoma: The patient, age seventy-one, was transferred from another hospital on October 28, 1945. There had been abdominal distress for two or three years, especially in the upper portion, similar to gallbladder dyspepsia. For the past three months there had been increasing pain in the lower abdomen and progressive constipation. There had been no rectal bleeding or melena. On October 1, 1945, she became ill with acute bowel obstruction. X-ray two days later showed "an irregular filling defect in the sigmoid colon with distention of the large bowel proximal to this obstruction. Diagnosis carcinoma of the sigmoid colon." She had been operated upon October 14, 1945, two weeks before admission to our service. "Attempt was made to deliver the transverse colon, but because of the distention this was considered dangerous. Wound closed. Small cecostomy was done through McBurney's incision." The patient was transferred to our service October 28th, fourteen days postoperatively, with a fever of 101.4°F. preceded by chills and a mild cough.

Examination on admission showed an acutely ill, senile, white female, with a temperature of

101.3°F. There were crepitant rales in the lower lung. Pelvic examination showed a narrow vagina and no cervix. Rectal examination showed a black stool; fullness was felt high up in the pelvis but no masses. Hemoglobin 80 per cent; red blood cells 4,980,000; white blood cells 8,450. Clinically she had hypostatic pneumonia. Penicillin, sulfadiazine and intravenous glucose were all given to no avail. She died November 27, 1945, three weeks after admission.

Postmortem abdominal examination revealed: cecostomy wound with subcutaneous sinus leading upward to a previous transverse right upper quadrant incision. "There was no free fluid in the abdomen. The main pathology was in the sigmoid. Here there was an inflammatory mass the size of a fist. It consisted of organized fibrous exudate, edematous angulated sigmoid colon adherent to itself and to the loops of the small bowel contiguous with it. Upon separation of these loops, a small perforation in the sigmoid was visualized, and a small amount of brown fecal matter oozed through the opening. The perforation had ulcerated the mucosa and produced a secondary stricture. The obstruction was due to edema about the ulcerated site, plus the inflammatory mass and the angulation of the sigmoid colon.

"The inflammatory process made recognition of the diverticulum which had perforated impossible, but one or two inches above this area there were two more diverticulae, one 5 mm., one 4 mm. in depth.

"Microscopic examination of the ulcerated area showed chronic inflammation with ulceration; loss of epithelium; fibrosis and infiltration of the adjacent bowel wall. No carcinoma was found in several sections."

*Comment.* Brown and Marcle<sup>5</sup> concluded that in one-third of the cases of diverticulitis symptoms were the result of inflammation while in two-thirds they were the result of inflammation plus obstruction. Sixty per cent give a history of constipation or constipation and diarrhea. The obstruction in diverticulitis occurs as a result of infection and edematous thickening of the gut wall and of the mesocolon and surrounding fat. "It is an extrinsic inflammatory reaction causing contraction of the external coats of the

bowel, in contradistinction to that produced by ulcerating carcinoma in which the contraction begins within and progresses outward" . . . "A sudden acute obstruction may arise even though the infectious process had been present in varying degrees for some time. If the attack does not subside there ensues a tremendous thickening of the mesentery and all the coats of the bowel which does not return to normal."<sup>6</sup> This narrowing plus adhesions and angulation frequently lead to obstruction.

This is the type which is frequently confused with carcinoma but the mass is usually larger and more tender. By x-ray the irregular pattern of bowel distortion is classically longer but x-ray uncertainty is well known.

At operation the mass may be excised for carcinoma, the true nature being discovered first on pathologic examination. D. F. Jones of Boston,<sup>7</sup> Tom Jones of Cleveland,<sup>8</sup> W. W. Babcock<sup>9</sup> among others have commented upon this diagnostic confusion. The more frequent mistake is to consider diverticulitis to be carcinoma rather than the reverse. None of the recent authors believe that diverticulitis is a precursor of carcinoma in any sense but the two occasionally coexist.<sup>10</sup>

CASE VI. J. K., hepatic cirrhosis mistaken for cancer of the colon: The patient, age fifty-one, was admitted on January 7, 1942. The transfer sheet from another hospital stated that x-ray had shown obstruction at the splenic flexure, ascites and large liver. Diagnosis was "suspicious colonic obstruction produced by a neoplasm and ascites from peritoneal implantation of metastasis."

His illness was of one and one-half years' duration, consisting chiefly of cramps in the lower abdomen, pains after meals, constipation and bright red blood in stools. Four months previously he noticed enlargement of the abdomen. During the past two months there had been weight loss and increasing weakness.

Admission examination revealed a chronically ill, white male with moderate dyspnea, cyanosis of the lips and edema of the lower extremities. There was marked enlargement of the abdomen with prominence of the super-

ficial veins, shifting dullness and fluid wave. The liver was not palpable at that time.

Laboratory data were as follows: hemoglobin 70 per cent; red blood cells 4,500,000; white blood cells 6,500; normal differential.

A barium enema on February 5th filled the entire colon. It was normal except for two small polyps in the ascending colon. Paracentesis on four occasions evacuated 10 to 14 L. of straw-colored fluid. There was very rapid reaccumulation of ascitic fluid following each paracentesis. A peritoneoscopy was done on March 7th. Liver biopsy revealed cirrhosis. Microscopically, there were hyperplastic liver cells separated into pseudolobules by small bands of fibrous tissue, which here and there at the periphery had infiltrating small round cells. He died five days later, probably of liver insufficiency and hypoproteinemia. No autopsy was allowed.

Cirrhosis is not uncommonly confused with abdominal carcinomatosis. Both exhibit abdominal distention, ascites, constipation, emaciation and prostration. The x-ray of the colon may be misleading.\* If the patient has a history of having used large quantities of alcohol over a long period of time, if the x-ray findings are inconclusive in search for a primary cause and if the ascitic fluid on tapping is clear and recurs very rapidly, cirrhosis may be suspected and the clinical suspicion verified by peritoneoscopy and liver biopsy. It is very difficult, however, to make this diagnosis in certain cases.

CASE VII. R. B., polyp of fundus uteri confused with carcinoma of fundus uteri: The patient, age fifty-six, was admitted June 20, 1945. She had had her menopause at the age of forty-two, fifteen years previously. She had been bleeding very intermittently for the past six years and for the past five months the bleeding had been more continued and slightly increased in amount. There was weakness and some loss of weight. There had been no pain. The general examination was negative

\* Saltzstein and Sandweiss<sup>11</sup> in 1921 reviewing twenty-two cases of cancer of the colon, all of whom died of the disease, found that 22 per cent of these cases had had x-ray examination which were indeterminate or negative. "A greater per cent of error was made in hepatic, transverse, and splenic flexure growths than in descending and ascending colon tumors."

except for some loss of weight. The uterus was relatively normal in size with a slight erosion anteriorly. Curettage brought forth normal endometrial mucosa in small amounts. No carcinoma was found. Gynecologic consultation found the uterus normal and it was suggested that 50 mg. of radium for seventy-two hours be used to stop the bleeding.

In view of the fact that a satisfactory explanation was not obtained for the postmenopausal bleeding, it was decided to do a laparotomy and a complete hysterectomy. This was done on June 25th. After removal of the specimen the endometrial cavity was opened. A small polyp was found at the top of the fundus. This was the apparent cause of the bleeding which had gone on intermittently for six years. Convalescence was perfectly satisfactory. Microscopic section of the uterine polyp revealed hyperplasia of the endometrium with the glands tortuous, hyperplastic and in papillary formation. No malignancy was demonstrated.

Only about 50 per cent of postmenopausal bleedings are due to cancer.<sup>12-15</sup> Of the benign lesions responsible for postmenopausal bleeding, cervical ulceration represents 10 per cent, postmenopausal vaginitis 7 per cent, cervical polyps 6 per cent, fibroids 4 per cent, endometrial polyps, endometritis, ovarian tumors, no pathologic change whatever, each represent a very small percentage.<sup>12</sup>

CASE VIII. Foreign body (sponge in abdomen), diagnosis: pelvic carcinoma: C. G., age fifty-six, was admitted August 9, 1945, with a diagnosis of abdominal carcinoma. The patient had had a laparotomy for some pelvic complaint twenty-five years before; two and one-half years later she underwent an emergency laparotomy for bowel obstruction. After this she had been apparently well until the past five or six years. Five years ago a diagnosis of duodenal ulcer was made and the patient was put on a diet. Since that time she had occasional epigastric pain and eructations, with flatulence. This always responded to an ulcer regimen consisting of diet, alkalies, etc. Hospital history at another institution stated "has had known gastric and duodenal ulcer for the past five years."



She had been fairly well until May 21, 1945, when she was seized with a sudden attack of fainting and passed a large amount of dark blood per rectum. She felt nauseated, seemed to taste blood but never had emesis. Since then she had frequent tarry stools almost daily. After four or five weeks of this she had been hospitalized at another institution. There her blood pressure was 95/60. A moveable mass 3 by 4 inches was palpable low in the abdomen and slightly to the left of the umbilicus. She was in some shock which was remedied with blood transfusions. X-ray of the stomach revealed no evidence of disease. A barium enema filled the entire colon. "We found no evidence of disease in the intestinal tract. There is a possibility of an extra colonic mass in the lower left abdomen which may have to be determined clinically." She was discharged after a few days.

However, within a week she had another severe hemorrhage from the rectum and was re-admitted to the above hospital on July 16, 1945. X-ray of the stomach and duodenum was repeated and was again negative. No source of bleeding was found. The suggestion was to have an x-ray of her chest and a gastric analysis. One consultant had suggested a laparotomy for a suspicion of carcinoma. This was not done. She was transferred to our service August 9, 1945. Consultants diagnosis on transfer chart was "pelvic tumor with fixation to the bowel which causes the hemorrhage. May have to resect bowel."

Examination on admission to our service revealed a very pale and bled-out woman, otherwise alert and active. Her hemoglobin was 3.5 Gm. or 21 per cent, red blood cells 1,430,000. She improved under repeated transfusions and her blood count finally went to 41 per cent (7.3 Gm.) red blood cells 2,280,000. A mass could at times be felt in the left lower or mid-abdomen but at other times it was absent. Our barium enema stopped in the lower sigmoid. It was decided to explore the abdomen, the diagnosis being far advanced carcinoma of the sigmoid.

Exploration revealed a normal, thin sigmoid colon free and clear throughout its extent. In the lower reaches of the ileum there was a mass the size of a small orange. It consisted of three matted loops of small bowel, plastered against a cyst-like cheesy inspissated mass. One loop of small bowel was easily detached. A second

loop was so involved that the serosa along one side had been destroyed. A third loop was intimately attached and there was an ulceration 1 cm. in diameter connecting the lumen of the small bowel with the mass. The mass was peeled away from the mesentery. It seemed to have a pseudocyst wall. It was not a dermoid but in the center was an old disintegrated laparotomy sponge. The bleeding had been caused by the ulceration into the small bowel. The ulcer was trimmed and closed, the second loop where the serosa was destroyed was excised and re-anastomosed. The patient made an uneventful recovery. On January 12, 1946, her condition was excellent. She had no complaints and bowel movements were O.K.\*

A sponge left in the abdomen at the conclusion of a laparotomy goes through a definite clinical course.<sup>16</sup> During the first month it is incidental to the inflammation and may suppurate and discharge either through the incision or through an abscess pointing into the rectum or vagina. After the acute inflammation has subsided the sponge is a foreign body and may extrude as such through a sinus, either externally or into the bowel, bladder or vagina. Later on the sponge is a well encapsulated foreign body (after two or three years).

The process of extrusion into the bowel happens in one-fourth to one-third of the cases and usually causes symptoms of indigestion and obstruction; that is, mild pain at irregular intervals, grading into violent colic with vomiting. In Crossen and Crossen's<sup>16</sup> review of 250 patients in whom a sponge had been left in the abdomen there was no report or mention of gross blood or serious bleeding into the bowel lumen.

On the other hand, a very small lesion in the jejunum or ileum may cause severe intestinal bleeding. Segal and Merle Scott<sup>17</sup> have recently called attention to this and mentioned one case in which a minute polyp in the ileum caused almost fatal hemorrhage. Large melena of obscure origin is well known and is a diagnostic problem which occasionally presents itself

\* This case has been reported in detail elsewhere.

in all general surgical clinics.<sup>18</sup> A sponge ulcerating into the bowel lumen twenty years after being left is apparently a rarity, but the confusion of hidden or obscure small intestinal bleeding with carcinoma of the bowel is not too uncommon. The diagnostic error frequently results from the fact that a lesion in the small bowel is so rare that it is not thought of as a diagnostic entity; often, therefore, no x-ray of the small bowel is obtained.

**CASE IX.** Jaundice due to common duct stone diagnosed carcinoma of pancreas: H. W., age 76, was admitted to our service on December 7, 1945. The patient was a senile old lady from whom no history could be obtained. Her daughter stated that she had been jaundiced for a short time prior to admission and that four doctors had told her that her mother had carcinoma of the pancreas. Physical examination on admission revealed a chronically ill, emaciated, senile white female with a moderate degree of icterus. There was a vague tender mass in the right upper quadrant. X-ray showed numerous gallstones in the gallbladder.

She was disoriented and confused and showed many evidences of central nervous system degenerative changes. Her jaundice slowly cleared almost completely and she ate well but usually dropped off into sleep after eating. After three weeks of this vegetative existence she became stuporous, lapsed into coma five days before death and quietly expired. Postmortem showed a dozen large stones in the gallbladder and one stone in the common duct; the pancreas was normal.

*Comment.* This is another instance of a senile old patient quickly put into the easy diagnostic hopper—far advanced cancer.

**CASE X.** Eczematous dermatitis of perineum and intertrigo mistaken for carcinoma of vulva: R. M., admitted February 6, 1946, age seventy-two, had been an inmate of a home for the aged in a city 60 or 70 miles away. She had complained of redness, swelling, burning in the perineum of three weeks' duration, associated with purulent vaginal discharge. The institution physician quickly diagnosed cancer of the uterus and she was transferred to our service for treatment of that condition.

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Examination showed a well nourished and well preserved old lady. Locally, the entire region of the perineum, vulva and medial aspect of both thighs was reddened, edematous and infiltrated with what grossly appeared to be an old inflammatory weeping lesion; there was no inguinal adenopathy. Laboratory data were: hemoglobin 13 Gm., red blood cells 4,100; white blood cells 11,000; urine negative; no sugar. The condition responded promptly to moist alkaline compresses, etc. In two weeks it had completely disappeared.

**CASE XI.** Loops of small bowel adherent in pelvis following irradiation for carcinoma of the cervix; death due to partial obstruction and inanition: G. S., age fifty-four, was admitted to our service on June 16, 1944. Subtotal hysterectomy and salpingectomy had been performed in 1934 for pelvic abscess. A vaginal bloody purulent discharge had been noted since September, 1943. In March, 1944, a microscopic diagnosis of adenocarcinoma of the cervix grade 4 was made. The patient received radium on two occasions (March 18 and April 1, 1944, 100 mg. in each dose). This was followed by deep x-ray therapy.

On admission examination to our service (two and one-half months after the second radium application) the patient was a fairly well nourished middle aged woman appearing chronically ill. There was marked irradiation pigmentation over the abdomen. The vagina easily admitted two fingers. The mucosa was pale; the cervix was taken in in the vaginal vault. There was no fixation of the parametrium and no induration about the cervical stump.

Intravenous pyleogram showed normal calyces and no obstruction of the ureters. Hemoglobin was 62 per cent or 10.5 Gm.; red blood cells 4,040,000; white blood cells 11,000. Admission diagnosis was carcinoma of the cervix and post-radiation sickness. (Previous radium and x-ray therapy three months ago.) She lay in bed under our care for three months. The nurses charting continued to note vomiting almost daily. At first the notes were "nauseated" and "slight emesis of greenish fluid." After about one month the notes began to state that the vomitus was brownish liquid. Every one, two or three days there was a note that the patient had had a bowel movement but still the nausea and emesis continued once or twice a day at least. In July she began to require more frequent narcotics. Her condition was

not good and at times she showed symptoms of drug addiction; she was noisy, cried out with pain which responded immediately to hypodermic injection. Her condition continued exactly as above with daily notation of emesis and relatively normal bowel movements without cathartics. About September 14th she began to be drowsy, required very few narcotics and slowly sank into coma and died on September 24th.

Autopsy revealed the following: uterus, tubes and ovaries not found, having been removed probably at the former operation. "There is an area of induration in the floor of the pelvis at the former site of the cervix. To this three loops of small intestine were adherent, as well as adherent to each other. The bowel at the site of each of these adherent regions presented a ring of bluish black, flattened, thin-walled mucosa. On separating these, perforation ensued. No gross carcinoma was seen here. There were no nodes felt or visible in the pelvis, but at the bifurcation of the right common iliac there was a firm node about 2 cm. in diameter, grossly appearing to be carcinoma. Microscopic examination of this node revealed metastatic carcinoma. There was also some atelectasis of the right lung."

*Comment.* In retrospect and review, this patient lay under our care for three months with a picture of partial small bowel obstruction, i.e., nausea and vomiting and pain in the abdomen but nevertheless had bowel movements. The diagnosis escaped us. We thought the continued vomiting and nausea due to (1) radiation sickness (2) drug addiction and (3) impending uremia seen so frequently in these cases. It is well known that because the contents of the small bowel are liquid, there can be considerable narrowing without the dramatic symptoms of obstruction; there is enough delay to cause nausea and vomiting and some abdominal discomfort and cramps but sufficient lumen to allow the passage of bowel movement.

The clinical syndrome of small bowel damage following irradiation therapy to cancer of the cervix is very well known and has been emphasized repeatedly in the past few years. It is especially liable to hap-

pen from irradiation of the cervical stump. The reasons are: The coils of the small bowel are very apt to be adherent in the pelvis from the previous hysterectomy, and the heavy shield which the uterine structures make between the peritoneal contents and the destructive effects of the radium is absent. In retrospect again, the indication would have been laparotomy and liberation of the adhesions of the small bowel.

At the time of death and at autopsy one gland at the bifurcation of the common iliac vessels on the right side was found to be carcinomatous. Taussig<sup>19</sup> found that in 23 per cent of borderline cervical carcinomas, malignancy persisted in the regional gland after heavy irradiation. In early and borderline cases he routinely dissected out the glands regional to the cervix, the inguinal nodes and those along the hypogastric and iliac vessels. Taussig could cure twenty-one per cent of those who had lymph node extension (a small series but all of these presumably would have died). Bonney obtained similar results with the radical Wertheim operation. (Quoted by Meigs.<sup>20</sup>)

There is a trend in several clinics today to revive the radical Wertheim operation or some modification in certain cases, chiefly those considered good risks, with the disease limited to the cervix, or irradiation-resistant tumors.<sup>20</sup>

CASE XII. Simple gastric ulcer causing exsanguinating bleeding: N. B., age eighty-two, was admitted to our service August 24, 1942. Admission diagnosis was probable carcinoma of the gastrointestinal tract. The patient was a senile old lady who was disorientated and confused so that history was difficult to obtain. She had had an operation, probably for an ovarian cyst, several years ago. She had lost fifteen pounds in weight the past nine months. There had been no emesis but she had had black stools for the past two or three weeks. There was also some constipation. Examination revealed an anemic, chronically ill, confused and disorientated old woman. She had bilateral parotitis. The abdomen was relatively normal. Hemoglobin was 25 per cent; red blood

cells 2,830,000; white blood cells 8,900; stools showed positive benzidine. X-ray examination was unsatisfactory because of the patient's condition. Fluoroscopy of the stomach did not show anything remarkable, but the barium enema showed a partial obstruction at the rectosigmoid junction. She gradually became weaker, did not vomit and slowly lapsed into coma and died quietly on September 18th, three weeks after admission.

Autopsy showed a shallow simple benign ulcer on the posterior wall of the stomach 2 cm. in diameter. The walls were smooth, sharp-edged and smooth-based.

Microscopic examination showed simple ulcer of the stomach with no atypical cell proliferation. Cecum and ascending colon were filled with reddish black contents which represented partially digested old blood. The barium enema appearance of the colon was explained by the autopsy finding of a long mesentery of the sigmoid colon tightly adherent to the parametria and uterus where the previous operative site had been. This was enough to produce angulation of the bowel which delayed the passage of barium per rectum.

*Comment.* Simple gastric ulcer in a patient this age is not common, but apparently in this instance it caused bleeding sufficient to exsanguinate the patient and she did not recover. As noted at the time of admission her hemoglobin was 25 per cent. There probably was continued seepage during the three weeks she was under our care. This is another instance in which a quick diagnosis of carcinoma was made in an elderly individual.

#### SUMMARY

Twelve cases are presented in which various non-cancerous lesions were confused with cancer: (1) Vesicovaginal fistula (traumatic) confused with cancer of the bladder; (2) encrustation cystitis confused with cancer of the bladder; (3) bladder calculus confused with cancer of the prostate (recurrent); (4) granuloma of the rectum confused with cancer of the rectum; (5) diverticulitis of the sigmoid confused

with cancer of the sigmoid; (6) portal cirrhosis confused with cancer of the colon; (7) polyp of the fundus uteri confused with cancer of the endometrium; (8) foreign body (sponge) in abdomen confused with cancer of the bowel; (9) gallstones confused with cancer of the pancreas; (10) dermatitis of the vulva and perineum confused with cancer of the vulva; (11) intestinal obstruction from radiation damage to bowel confused with the terminal stage of cancer of the cervix; and (12) hemorrhage from simple gastric ulcer confused with gastrointestinal cancer.

#### CONCLUSIONS

In view of such experiences as the above, we have formulated certain rules to guide us in the diagnosis and treatment of this type of patient:

1. *Accept no diagnosis unless absolutely proven* either by biopsy or other satisfactory method. Cancer is one diagnosis which must be established one way or the other. It does not permit or allow guessing. An error may mean a patient's life. The evidence on which the diagnosis is based including the radiograph and the microscopic section, etc., must be critically examined; if indicated these should be repeated.

2. *A period of observation* may be necessary before a correct and final diagnosis can be established.

3. *Laboratory findings are only diagnostic aids.* If they do not fit in with the history and clinical findings, they should be reviewed, repeated or investigated further.

4. *If the clinical history does not coincide with the natural course of the disease,* question one or the other. A new and unsuspected approach may be discovered.

5. After all diagnostic procedures, observations, etc., are exhausted and there is still uncertainty, surgical exploration may have to be seriously considered if the patient's condition warrants.

6. *An apparent recurrence* in a patient who previously may have had cancer, may be a new and perhaps non-malignant lesion.

July, 1949

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# GIANT FOLLICULAR LYMPHOBLASTOMA OF THE APPENDIX\*

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THE purposes of this paper are to report a case exhibiting a lesion which is rarely found in the appendix, to correlate this case with similar ones already reported and to point out the probable identity of this lesion with one which is now recognized as the distinguishing feature of a definite disease entity.

## CASE REPORT

A thirty-four year old negro housewife was hospitalized May 2, 1943, because of disturbances in the rhythm and volume of her menstruation and because of recurrent attacks of abdominal pain.

Her menstrual cycles were normal from their onset at the age of twelve until the last year before hospitalization except for an interval of nine months of amenorrhea ending in the delivery of a stillbirth in 1931. Thereafter she had an intermenstrual brownish vaginal discharge which took on an offensive odor as her menstruation changed. At first there was a gradual prolongation of each flow, increasing from four or five days to seven or eight. During the last two months before hospitalization she flowed twice each month, passed numerous clots and experienced pre- and co-menstrual pain.

Early in 1940 the patient had an attack of epigastric pain associated with a sensation of hunger and relieved by the intake of food. For one year there were recurrent similar attacks which were relieved at first by the intake of food and later by the use of milk of magnesia. Under the latter treatment the attacks disappeared in 1941 and did not return. On February 19, 1943, the patient experienced a sharp pain in the right lower quadrant which radiated to the umbilicus. During the attack, which lasted two days, the patient's appetite remained good. She noticed that the pain became intensified whenever she ate, that she became nauseated whenever her stomach was full and

that vomiting caused relief from both the pain and the nausea. An electric treatment given by a private physician for what he termed an "infected ovary," aggravated her condition. Without additional treatment the symptoms disappeared and the patient felt well except for constipation. A second attack on March 13, 1943, was associated with diarrhea. For this and later similar attacks she attended a public clinic and was treated by another physician without lasting benefit. The last attack, experienced on May 1, 1943, and characterized by severe pain in the right lower quadrant, nausea and vomiting, caused her to be referred to the hospital, with a tentative diagnosis of recurrent appendicitis.

The patient denied upper respiratory infections or swelling of lymph nodes in relation to these attacks. There had been no deaths in her family from diseases of lymphoid tissue. The members of her immediate family were all living and in good health.

Physical examination revealed a moderately obese woman who appeared to be in good health. There was no swelling of superficial lymph nodes. Pertinent findings were: tenderness in the right lower quadrant and a mass felt in the lower abdomen; a relaxed but intact perineum; enlargement of the uterus upward and to the left attaining the size of about a four months' pregnancy; a slightly enlarged, freely movable cervix which was painless when manipulated; pain on movement of the uterus; tenderness in the parametrial regions but no masses were identified; a thick, purulent discharge from the cervical os and Nabothian cysts in the anterior lip of the cervix. Rectal examination failed to reveal additional changes.

Laboratory examinations of the urine and blood revealed the urine to be normal; serology (Hinton and Eagle) was negative; red blood cells, 5,670,000; white blood cells, 5,400; polymorphonuclear, 71 per cent; mononuclears, 29 per cent; sedimentation, 8 mm. in fifteen minutes, 16 mm. in thirty minutes and 18 mm.

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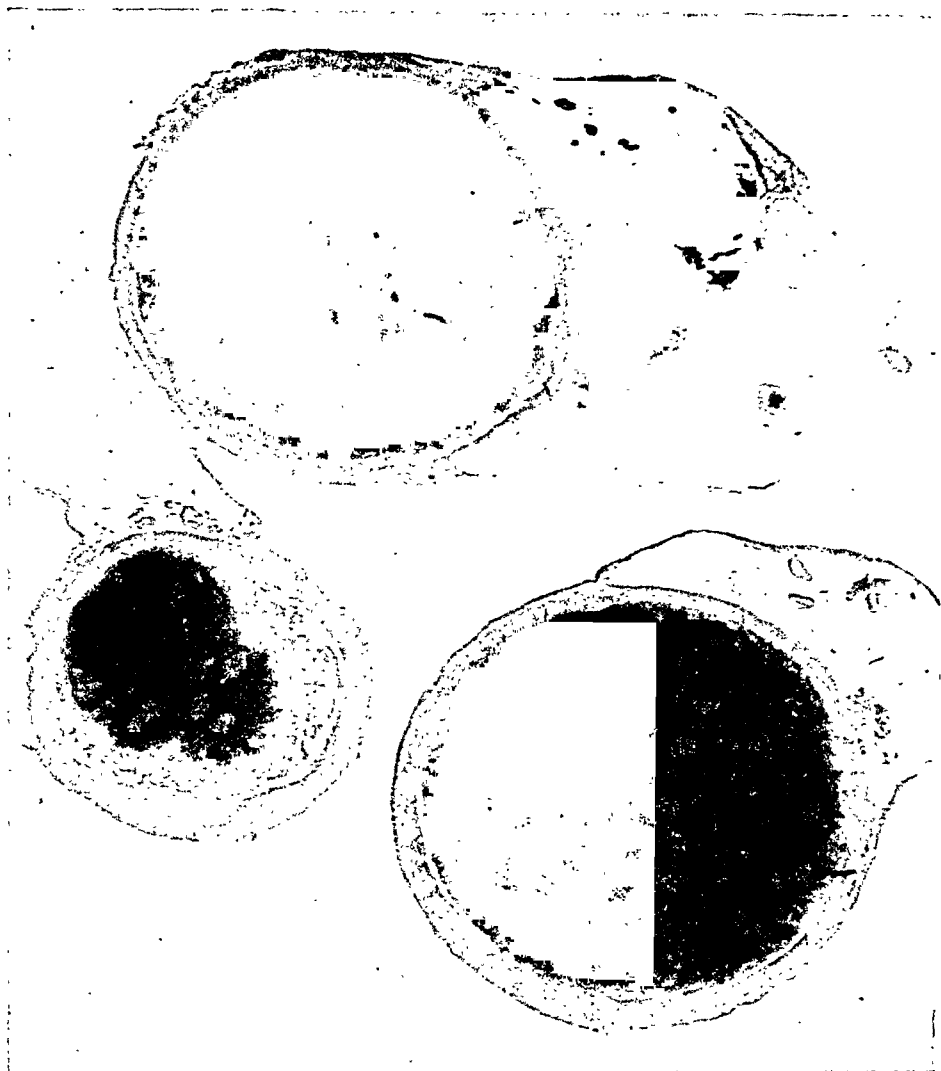


FIG. 1. Sections of the proximal, middle and distal thirds of the appendix, revealing hyperplasia of lymphoid tissue. The lumen is obliterated; the mucosa has disappeared entirely; in the section from the middle third the lymphoid tissue has spilled into the meso-appendix without destroying the muscle coats and a thin layer of submucosa; the process consists of a numerical and spatial hyperplasia of the lymph follicles.

in sixty minutes (Wintrobe method not corrected).

The patient was operated upon on May 7, 1943, under general anesthesia with the clinical diagnoses: fibromyomas uteri, bilateral salpingitis and recurrent appendicitis. Her condition during the operation was good. The findings at operation were: adhesions binding the omentum to the pelvic peritoneum, a cyst of the left ovary, distention of the left tube, enlargement of the uterus by subserous and intramural fibromyomas and enlargement of the middle and distal thirds of the appendix.

The adhesions were separated by blunt and sharp dissection. The uterus was removed supravaginally together with the left tube. The

ovarian cyst was enucleated and the appendix was removed.

Postoperatively the patient ran a low grade temperature for five days and thereafter recovery was uneventful. She was discharged on May 17, 1943. When last seen on May 25, 1946, the patient appeared well and had no complaints. There were no enlargements of superficial lymph nodes.

The gross and microscopic findings in the pelvic organs were summarized by the pathologist as follows: subserous and interstitial fibromyomas of the uterus, healed left salpingitis with residual hydrosalpinx, serous cyst with compression atrophy of the left ovary and corpus hemorrhagicum of the right ovary

associated with endometrium in the late corpus luteum phase of the menstrual cycle.

The appendix was found to be 8 cm. long with smooth serosa, injected serosal vessels and moderately abundant adipose tissue in its mesentery. It had a diameter of 8 mm. in its proximal third and from 10 to 11 mm. in the middle and distal thirds. It was not readily compressible and when sectioned its lumen was found to be obliterated by a whitish growth. Microscopically, the lumen was obliterated, the mucosal epithelium was missing and its submucosa and muscle coats were compressed by an impressive growth of lymphoid tissue consisting of a numerical and spatial hyperplasia of its follicles and germinal centers. In one of the three sections studied the hyperplastic lymphoid tissue was found to have spilled over into the meso-appendix, sparing almost entirely the intervening and compressed muscle and submucosal coats. (Figs. 1 and 2.) The impressions of the pathologist were: tumor of lymph follicles (lymphoid folliculoma) of the appendix with obliteration of the lumen and invasion of the meso-appendix. A review of the available opinions on diseases of lymphoid tissue led to a final diagnosis of giant follicular lymphoblastoma.

#### COMMENT

In the references available to us when the case was first studied there were reports of only six patients exhibiting lesions of the appendix of the type herein reported.<sup>3,9,11,12,17</sup> The pertinent data on these cases, on three others reported recently<sup>10</sup> and on our own are presented in Table 1. In addition to these allusions have been made to at least four other cases which appear to be of the same type. Lehman<sup>9</sup> refers to two, the case of Müller and another described by Pigot, and the other two are cases iv and v of Gruenwald<sup>6</sup> who reported recently on five instances of abnormal follicles in the digestive tract. We have been unable to find the original descriptions of the cases to which Lehman referred. His brief reference to them does not include their symptoms or a full description of their appendiceal lesions. Similarly, Gruenwald does not include clinical pictures of his cases. Moreover, his reports

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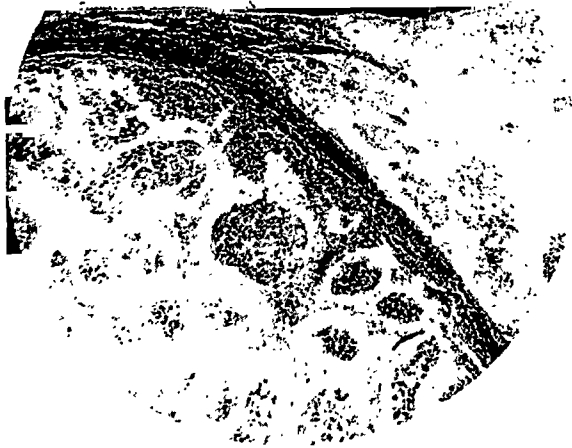


FIG. 2. Higher magnification of a part of the section made from the middle third of the appendix.

on cases iv and v do not include photomicrographs of their appendiceal growths and his description of the lesion in case v is not very clear.

It is apparent from the table that these cases exhibit a wide range in age incidence and that they are equally divided as to sex. It is apparent also that the lesions may be nodular, pedunculated or diffuse and that they may merely fill the lumen of the appendix or obliterate it either locally or in its entirety. As a group these cases deserve special study because these lesions may mimic appendicitis or appendicitis may be exhibited as a complication. They present a very special problem in diagnosis.

It is probably true that in the field of diagnosis there is no sector which is hedged in with more difficulties than that borderland between inflammatory hyperplasias and neoplasms. This is particularly true where lymphoid tissues are concerned<sup>4</sup> and is well exemplified by the cases under consideration.

Wilhelm and Delval,<sup>17</sup> the first to describe this entity, considered it to be an inflammatory tumor of the appendix. Because the appendix is so frequently the seat of inflammation, one is tempted at first to agree with them. However, a second thought must cause one to doubt that in-



flammation could have any etiologic relationship with the lesion described herein because it has been found very rarely in an organ which is inflamed so frequently and is so accessible surgically that it has been submitted to gross and microscopic

Wilhelm and Delval and Lehmann and Gruenwald, however, Morehead and Woodruff recorded the impression, "In each instance the microscopic picture was that of simple lymphoid hyperplasia."

Brill, Baehr and Rosenthal<sup>2</sup> reported in

TABLE I

Case No.	Authors	Year	Age	Sex	Clinical Data								Pathologic Data		
					Pain in Right Lower Quadrant	Nausea	Vomiting	Tenderness in Right Lower Quadrant	Rigidity or Resistance	Temperature	Diarrhea	Constipation	Urinary Frequency or Urgency	Inflammation	Adhesions
I	Wilhelm and Delval	1910	17	M	+	..	+	+	..	+	..	..	-	*	Pedunculated growth at tip
II	Lehmann	1925	20	F	+	+	..	..	..	+	..	..	-	..	Nodule in distal third
III	Stout	1927	8½	F	+	..	+	+	..	+	..	+	+	..	Nodular enlargement at base; acute inflammation distally
IV	Stout	1927	9	F	+	+	..	+	..	+	..	+	-	..	Distal half obliterated by growth
V	Evans	1931	55	M	+	..	+	+	..	..	..	+	-	..	Nodule at base causing swelling
VI	Ruggieri	1938	39	M	+	+	+	..	..	..	..	..	-	+	Proximal third obliterated and enlarged by growth; distal two-thirds obliterated by fibrosis
VII	Morehead and Woodruff	1945	33	F	+	+	+	+	+	..	..	..	-	-	Distal third obliterated and enlarged by growth
VIII	Morehead and Woodruff	1945	12	M	+	+	-	+	-	..	..	..	+	+	Distal third obliterated and enlarged by growth; diffuse infiltration by eosinophils proximally
IX	Morehead and Woodruff	1945	26	M	+	..	..	+	+	..	..	..	-	+	Distal third obliterated and enlarged by growth
X	Jason and Malloy	?	34	F	+	+	+	..	..	..	+	+	-	-	Distal two-thirds enlarged; entire lumen obliterated by growth

\* Case I, Appendix retrocecal

study about as frequently, if not more frequently, than any other internal organ.

Since the report by Wilhelm and Delval and before that by Morehead and Woodruff,<sup>10</sup> the condition had been labeled polyposis due to hyperplasia of lymphoid tissue, lymphoid hyperplasia, lymphoma, benign lymphoblastoma and abnormal accumulations of lymph follicles. It seemed to us, however, that a more accurate opinion about the nature of the lesion which these cases exhibit might be obtained if reference were made to similar alterations found in other lymphoid tissues of the body. Such an opinion led to our final diagnosis in the case reported herein and it is embodied in the paper by Morehead and Woodruff who interpreted the growths found in their three patients as examples of solitary giant follicular lymphoma of the vermiform appendix. In alluding to the cases reported by Stout,<sup>12</sup>

1925 a "hitherto undescribed condition" which they characterized as a generalized lymph follicle hyperplasia of lymph nodes and spleen. Symmers<sup>13</sup> reported on the same condition two years later. Since then the name Brill-Symmers disease has been applied to it and a fairly complete picture of the disease has evolved from new reports and follow-up studies of the older cases. It is now admitted that (1) although the interest of the medical profession in this condition was aroused by the reports of Brill, Baehr and Rosenthal and Symmers, there had been earlier descriptions of its characteristic lesions, probably the earliest being that of Becker<sup>1</sup> in 1901; and (2) whereas originally the disease was considered to be benign, later evaluation revealed cases which became undeniably malignant.<sup>14,15</sup>

The characteristics of Brill-Symmers disease as originally conceived and as

modified by later studies are described in sufficient detail elsewhere.<sup>1,7</sup> It is well to point out that the disease is of insidious onset, consisting of a localized or multicentric enlargement of lymphoid tissues due to a numerical and spatial hyperplasia of their follicles and germinal centers. It may occur at any age (reported range from two to seventy-seven years). It runs a benign course for a very long time and may either remain so and heal or may become malignant in character. During its benign course the lesion is highly radio-sensitive; the patient appears in good health, does not exhibit either anemia or cachexia nor does he have abnormal cell forms in the blood. There is a tendency toward involvement of the lacrimal glands and occasionally the lympho-epithelial structures of the digestive system are affected.

Having in mind these and other characteristics of Brill-Symmers disease,<sup>7,8</sup> it becomes readily apparent that the several cases under consideration correspond perfectly to the early stages of that form of the disease in which there are only localized lesions. There are no positive findings in either one of the two groups of cases which can justify their separation as distinct clinical or pathologic entities. Their lesions are identical and the cases reported herein are distinguished solely by the fact that their lesions occurred in the appendix and thereby modified the clinical course.

While attempting to justify the inclusion of these cases within the scope of Brill-Symmers disease, it must be borne in mind that there are no adequate follow-up studies on any of them. Even the case reported herein has been followed for only three years which is more than half the average duration of the cases of Brill-Symmers disease which have terminated fatally (4.8 years). This, however, is not considered to be sufficient basis for their exclusion not only because of the impressive similarity, if not identity, of their microscopic lesions, but also for the reasons which follow.

Symmers<sup>15</sup> recorded his impressions to the effect that the disease named in part after him, at least in its early stages, naturally is inclined in the direction of benignancy and that spontaneous diminution in size of the nodes or apparently complete disappearance may occur. He added that this may happen even late in the course of the disease. In this connection it is to be remembered that patients may tolerate enlargements of superficial lymph nodes for a long time without seeking medical treatment, particularly so if these are not associated with pain or other disturbances of their well being. It is to be remembered, too, that the appendix in the presence of hyperplasia of its lymphoid tissues is not likely to remain symptomless quite as readily as superficial lymph nodes.<sup>15,16</sup> It is highly probable, therefore, that cases of Brill-Symmers disease which have their initial lesions in the appendix will become evident clinically at an early stage in their development and, therefore, may be cured by the surgical removal of this organ. Moreover, since appendectomies are such relatively common operations, the finding of an appendectomy scar in a patient exhibiting the lesions of Brill-Symmers disease in their usual localizations is not likely to excite suspicion of an earlier manifestation of the disease in this organ so that an attempt at correlation is not likely to be made.

#### SUMMARY

1. A case report is made of a patient whose appendix had its lumen obliterated by a giant follicular hyperplasia of its lymphoid tissue.
2. Correlation with nine reported cases reveals the features these exhibit in common as well as their variations.
3. An attempt to identify the condition exhibited by these patients leads, on morphologic grounds, to its inclusion within the term giant follicular lymphoblastoma (Brill-Symmers disease) as suggested by Morehead and Woodruff for their three cases.

4. The belief is expressed that these cases, revealed early in the evolution of the disease because of the occurrence of the lesion in the appendix, may have been cured by appendectomy while the disease was still localized.

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# INTESTINAL OBSTRUCTION DUE TO MESENTERIC HIATUS\*

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**A**CUTE intestinal obstruction can be caused by the incarceration of a loop of bowel through an aperture in the mesentery. Although such a defect is uncommon, it should be considered in evaluating the possible causes of a bowel obstruction when the etiology is obscure. The condition has never been diagnosed before operation. The following case history is submitted as an addition to those already cited in the literature.

## CASE REPORT

Mrs. M. L., No. 8804, eighty-eight years old, a resident of the City Home, was admitted to the Second Surgical Division of Goldwater Memorial Hospital on May 10, 1946, complaining of abdominal pain and vomiting for six hours. She had not moved her bowels for twenty-four hours but she had been able to expel flatus. There had been some weight loss during the preceding six months but her appetite continued good until the onset of her illness. There had been no melena. During a previous stay at the hospital from May 2, 1944, to January 3, 1945, she was treated for generalized arteriosclerosis, hypertension, chronic myocarditis and diffuse osteoarthritis of the spine.

Upon examination she did not appear acutely ill or in pain. Her temperature was 98.6°F., her pulse was 80 and her respirations 18. The heart was somewhat enlarged, the rate was regular and there were no murmurs. The blood pressure was 170/100. The lungs were clear. Her abdomen was slightly distended in the lower half but soft throughout. There was no visible peristalsis. There was mild diffuse tenderness and this was most marked in the right lower quadrant. An abdominal mass could not be palpated. Digital examination failed to show stool in the rectum. The blood count showed red blood cells 4,000,000 and white blood cells 12,000 with 80 per cent polymorphonuclear cells and 20 per cent lympho-

cytes. The hemoglobin was 75 per cent (Sahli). On May 11th roentgen ray examination of the abdomen demonstrated moderate dilatation of several coils of small intestine but a repeat study on May 13th showed an increase in the amount of gaseous distention and the appearance of fluid levels.

During the first twenty-four hours of her stay at the hospital the patient refused all treatment. She vomited small amounts of brown, odorless fluid. She continued to pass flatus but stool could not be obtained by enema. On the day of admission the tentative diagnosis was incomplete intestinal obstruction due to a tumor in the colon at the hepatic flexure. Conservative treatment was instituted in order to allow more accurate diagnosis and definitive treatment. However, stomach tube suction and rectal irrigation did not diminish her abdominal distention; and since roentgen ray study showed an increase in the number of distended loops of small intestine, it was decided that her obstruction had become complete and surgical therapy was mandatory.

Operation was performed on May 13, 1946, under combined local infiltration with 1 per cent procaine and cyclopropane inhalation anesthesia. The abdomen was entered through a gridiron incision in the right lower quadrant. The wound was enlarged toward the midline by incision of the sheath of the rectus abdominis. The peritoneal cavity contained a small amount of clear straw-colored fluid. The cecum and ascending colon contained a small amount of gas. About 20 cm. from the ileocecal junction there was an oval opening in the root of the mesentery of the ileum about 6 cm. in diameter. Its edge was smooth and rounded. A loop of ileum, 30 cm. long, had slipped through this hiatus and had rotated itself clockwise for about 170 degrees. The involved loop was distended but not discolored and the intestine proximal to the site of obstruction was moderately dilated. Immediately after reduction of the volvulus gas passed into the terminal ileum and cecum. The efferent arm of the

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incarcerated loop was adherent to the border of the mesenteric defect but was easily separated from it and then extracted from the opening. The patient's general condition was poor so that the operation was terminated without closing the mesenteric hiatus. The abdomen was closed in layers without drainage.

Supportive therapy was continued during and after the procedure but her condition became rapidly worse and she died eight hours after operation in apparent shock and cardiovascular collapse. Permission for autopsy was not obtained.

#### COMMENT

This case of incarceration of a loop of small intestine into a mesenteric hiatus is especially interesting in that it occurred in a patient at the age of eighty-eight. Since there had been no preceding operation or trauma, it is reasonable to postulate that the defect was congenital. Iagnov and Timus in an extensive discussion of this condition state that the available evidence indicates the congenital nature of mesenteric hiatus.<sup>2</sup> During the development of the fetus, portions of the mesentery are absorbed as the intestines rotate to assume their normal positions.<sup>4</sup> Defects may appear during this process.

The most frequent site for a mesenteric defect is near the ileocecal junction.<sup>2</sup> Such a location is illustrated by the case reported herein. Most of the cases in the literature showed strangulation of the involved intestine but this did not occur in our patient.

No evidence could be found in the literature of an accurate anatomic preoperative diagnosis of mesenteric hiatus. A review of our case and others<sup>1,2,3</sup> shows that the sudden onset of intestinal obstruction was the first indication of intra-abdominal disturbance. An exception to this was found

in one patient who gave a nine-year history of occasional nausea and cramps after meals.<sup>2</sup> The possibility of a mesenteric defect in a patient who suddenly develops an obstruction of the small intestine without apparent cause must be kept in mind. Unfortunately there are no specific findings indicative of obstruction caused by such defects.

The treatment of mesenteric hiatus is essentially the treatment of the complicating intestinal obstruction. When possible, the defect should be closed.

A discussion of the cause of death of our patient is not appropriate to this report but lies within the scope of the larger problem of intestinal obstruction. It should be noted, however, that of the four cases reported by Watson,<sup>1</sup> Iagnov and Timus<sup>2</sup> and Baty<sup>3</sup> only one patient survived.

#### SUMMARY

1. A case of obstruction of the ileum due to its incarceration in a mesenteric hiatus is presented.
2. Mesenteric defects, without preceding trauma, are rare and probably congenital.
3. They should be suspected in cases of acute intestinal obstruction without a preceding history of intestinal disease.
4. The treatment of mesenteric hiatus is the treatment of the intestinal obstruction and the closure of the defect.

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# HEMATOMA OF THE SCROTUM

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THIS case is reported because of its unusual character. A healthy young soldier with no evidence of local disease or direct trauma to the scrotum developed a hematoma of the scrotum after lifting.

## CASE REPORT

R. H., age nineteen, white, was admitted to the hospital at 9:15 P.M. by ambulance on July 28, 1947. Two hours before admission he had lifted his foot locker and felt a sharp agonizing pain in the left groin; he fell to the floor. His barracks mates lifted him and put him on the bed where he lay for some time. He noticed a swelling forming in his left scrotum and an ambulance was sent for.

Two weeks previously in the course of doing similar duties requiring heavy lifting, the patient had felt a sharp pain in his left groin. At this time he had stopped lifting, rested and the pain had disappeared.

Examination at 9:45 P.M. showed a globular mass in the left scrotum, doughy in consistency and tender to examination. It did not transilluminate. The left external inguinal ring was tender; the right scrotum was normal.

There had been no previous history of varicocele or hernia and no history suggestive of blood dyscrasia in the family.

Physical examination showed a large, well developed, well nourished, blonde, young adult. The skin was flushed and the skin about the trunk and legs showed scattered papules (miliaria). Head, neck, throat, nose and eyes were all normal. Examination showed the heart and lungs to be normal; the abdomen was flat and there were no masses, tenderness or rigidity; sounds of peristalsis were normal.

The patient was taken to the operating room and under spinal anesthesia it was noted that the testicle could be outlined from the mass. A low parainguinal incision was made. A small hematoma within the spermatic cord about 1 inch below the external inguinal ring was noted and removed. There was much oozing of the structures about the inguinal canal.

Structures of the spermatic cord were dissected and there was no evidence of a hernial sac. The veins of the pampiniform plexus seemed normal. The left testicle was lifted out of the scrotum and a large hematoma  $3\frac{1}{2}$  inches in diameter was seen attached to it infiltrating the median raphe. The hematoma was dissected away *en masse* removing strands of fatty tissue intimately connected with it.

The tunica vaginalis was opened and found to be perfectly normal and small in size. It was inverted and sutured. The scrotum was irrigated and the testicle reintroduced into it. Thrombin-soaked pieces of fibrin foam were placed around the testicle in the scrotal cavity and in the region of the inguinal canal in order to prevent a recurrence of hematoma from generalized oozing. Transversalis fascia was sewed to the shelving edge of Poupart's ligament as was the conjoined tendon. The external oblique aponeurosis was sewed over the cord reconstructing the inguinal canal.

Laboratory study showed the urine to be negative, white blood cells 9,400, hemoglobin 95 per cent. The differential count was 64 per cent polymorphonuclear cells, 31 per cent lymphocytes and 5 per cent mononuclear cells. Clotting time was two minutes, bleeding time one minute twenty seconds. Prothrombin time was thirteen seconds as against the control of fourteen seconds. Rumpel-Leeds test was found to be negative.

The postoperative course was uneventful. Early ambulation was not applied in this case. A pressure dressing was placed around the scrotum after operation and retained for three days. Sutures were removed on the seventh postoperative day. The scrotum remained normal in size throughout the postoperative period. A small amount of edema was noted about a week following operation on the left posteromedial side of the scrotum. A pyramidal mass above the left testicle was noted during the second week due to induration of the inverted tunica vaginalis. Examination on August 15th showed the testicle entirely normal.

## COMMENT

This case is exceptional in that a large hematoma formed in the scrotum without any evidence of direct trauma; the incident that led to the condition was the lifting of a heavy locker. A possible rupture of a varicocele by this exertion is to be considered but there is no evidence of varicocele by previous history or examination, nor by the examination at the time of operation. The fact that the bulk of the hematoma was entirely outside the spermatic cord also makes varicocele improbable.

Another possible mechanism of injury by the sudden lifting could be a result of muscle pull. Cremasteric fibers attached to the external surface of the spermatic fascia could pull suddenly in consonance with the internal oblique muscle and a tear of the attached loop of fibers might occur. Such a pull can be so sharp as to conflict with the inertia of a low dependent testicle. It may meet such resistance of the scrotal ligament as to cause a tear of the vascular and nerve plexus which is said to be present there. In hot weather the surface temperature of the body will be increased, the muscle tone of the dartos muscle will be lessened and make the scrotum markedly dependent. The fact that fractures of bone are known to occur as a result of direct muscle action makes it reasonable to postulate such a mechanism here.

Surraco<sup>1</sup> points out that the scrotal ligament forms a plexus of arteries, veins, lymphatics and nerves and it is an area of lesser resistance in the scrotum. It is very likely to be the source of hematoma forma-

tion with any direct injury to the scrotum or testicle. He advises block excision of the hematoma as if it were a tumor.

In this case the pain was so acute and agonizing that the patient fell to the floor indicating that an area of generous nerve supply had been affected. The history showed that a similar milder incident which had not been followed by the tumefaction of hematoma occurred two weeks previously. This suggests that the patient was affected by some variation in anatomy of the inguinoscrotal region that could cause his cremaster to act more sharply than is usual.

The spermatic fascia<sup>2</sup> which is a continuation of the transversalis (or endo-abdominal) fascia and the loop of cremaster muscle fibers (continuous with the internal oblique muscle) adhere to the external surface of the parietal layer of the tunica vaginalis. Surraco believes that the potential space between the spermatic fascia and the cremaster fibers is the locus for the formation of hematoma. But tear of the cremaster fibers would break such a limiting boundary and extend the effusion into the scrotal space of dartos connective tissue.

## CONCLUSION

An unusual case of hematoma of the scrotum following lifting is reported. A probable mechanism of pathogenesis is described.

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# New Instruments

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## THE FALLACY OF THE SO-CALLED THYROID CAPSULE\*

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Chicago, Illinois

A SURGEON needs only to perform his first few thyroidectomies to realize the fallacy of the concept that a well defined capsule completely encircles the thyroid gland. The idea that the gland can be readily enucleated as soon as this capsule or sheath is entered is morphologically and surgically incorrect. It is true, however, that specific cleavage planes do exist which can be utilized surgically if one understands the fasciae surrounding the thyroid which form a sheath of areolar tissue with definite attachments to the gland.

Many accounts of the arrangements of the fascia of the neck have been presented and studied; those in the standard textbooks of anatomy are too well known to bear repetition. However, most of these descriptions tend to complicate rather than clarify the picture. The observations presented herein represent the result of research and observations over a ten-year period taken from dissecting, postmortem and operating rooms. It is on the living patient that the surgeon may verify the description submitted herein.

Certain general principles governing the arrangement of fasciae must be kept in mind. If these facts are appreciated, the cleavage planes which exist will not be looked upon as artifacts. Among such principles one must recall that most skeletal muscles are surrounded by fascia (exceptions to this are those which lie upon bone, cartilage, etc.). The strength of fascial en-

velopes varies tremendously; some appear as strong closed investments which form a sheath while others appear as only a thin enveloping layer. When two muscles overlap one another, the fascial layer separating them is common to both. Meyers and Macpherson<sup>1</sup> are of the opinion that this last mentioned fact is of paramount importance and has been lost sight of. We wish to emphasize this point since we are of the opinion that the fascia associated with the deep surface of the sternothyroid muscle is so closely related to the anterior lamella of the pretracheal fascia that they are at times fused and, therefore, are incised as a single structure. The fascia must be regarded as a specific living structure which can respond to stimuli in its own way. If this fact is kept in mind, fascia becomes a definite structure to be identified in the course of a well planned thyroidectomy. This discussion shall be kept only within the bounds of those regions which pertain to thyroid surgery.

*Deep Cervical Fascia.* The deep cervical fascia (fascia colli) consists of three layers (Fig. 1B), (1) a superficial or general investing layer; (2) a middle or pretracheal layer; and (3) a deep or prevertebral layer. These layers may fuse in the midline. The degree of fusion is dependent upon the amount of divergence of the infrahyoid muscles and on the number and arrangement of the anterior jugular veins which are situated between the fasciae of the sternomastoid and the sternohyoid muscles.

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*General Investing Layer.* The general investing layer is characterized by its ability to split and envelope muscles, namely, the trapezius and sternomastoid. Posteriorly, it is attached to the ligamentum nuchae and splits immediately to enclose the trapezius at the anterior border of which it reunites, thus forming the fascial roof of the posterior triangle of the neck. Reaching the posterior border of the sternomastoid, the fascia again splits to form an envelope for this muscle. The two layers again join, continue forward as the roof of the anterior triangle and become continuous with a similar layer on the opposite side. The general investing layer attaches above to the external occipital protuberance, superior nuchal line, base of the mastoid process, zygomatic arch and lower border of the mandible. It is attached below to the manubrium sterni, clavicle, spine of the scapula and the acromion process. In this way the superficial layer of the deep cervical fascia forms a circular tube which holds the structures of the neck in place. Everyone seems to be agreed upon the existence and arrangement of this layer.

*Pretracheal Layer.* The middle or pretracheal layer of deep cervical fascia is the one of greatest surgical importance. The sternohyoid and omohyoid muscles are situated in the same plane but the sternothyroid muscle is situated in the plane immediately subjacent to these. In this instance the pretracheal fascia supplies investments for the sternohyoid and omohyoid muscles, forms a loose areolar tissue cleavage plane beneath these and finally supplies a fascial envelope for the deeper lying sternothyroid. This areolar tissue which is found on the deep surface of the sternothyroid muscle is intimately related to the anterior lamella of pretracheal fascia which forms the anterior part of the sheath of the thyroid gland. It is because of this arrangement that the proper cleavage planes can be utilized in mobilizing the thyroid gland rather than following the fallacious thought that a separate thyroid capsule completely encircles the gland.

Therefore, we note that when one identifies the sternothyroid muscle as a separate structure and dissects posterior to it, he automatically breaks through this sheath and exposes the thyroid gland. Although the surgeon has entered the proper cleavage plane and has incised the sheath, he cannot mobilize the thyroid lobe completely because of the lateral attachments of the pretracheal fascia. These attachments can best be described if one considers the pretracheal layer of deep cervical fascia in the following way: the pretracheal layer is considered an offshoot of the general investing layer.<sup>2</sup> It then passes horizontally in front of the carotid system. As it continues medially the fascia splits into two layers, a prethyroid layer (lamina) and a pretracheal layer (lamina) proper.<sup>3</sup> (Fig. 2B.)

The prethyroid layer of pretracheal fascia is a thin anterior lamina which extends medially. It is loosely attached to the gland along an irregular line which is located at the junction of the middle and posterior thirds of the superficial surface of the lateral lobe. At the upper pole it extends medially, anterior to the superior thyroid vessels and, toward the midline, firmly blends with the pretracheal layer proper of pretracheal fascia. At the lateral margin of the pyramidal lobe it again divides from the pretracheal fascia, extends over the anterior surface of the pyramidal lobe and blends with the prethyroid fascia from the opposite side. Inferiorly, the prethyroid fascia is attached to the gland along a line which extends around the lower pole and across the inferior margin of the isthmus. In this region it supplies an anterior covering for the inferior thyroid veins. Lateral to the thyroid gland this lamina is separated from the pretracheal lamina proper by a triangular space which is filled with loose connective tissue and which Sloan<sup>3</sup> has referred to as the postthyroid space. The sides of this anatomic triangular space are formed by the prethyroid fascia anteriorly, the pretracheal fascia proper posteriorly and the thyroid gland medially. (Fig. 1B.) It extends along

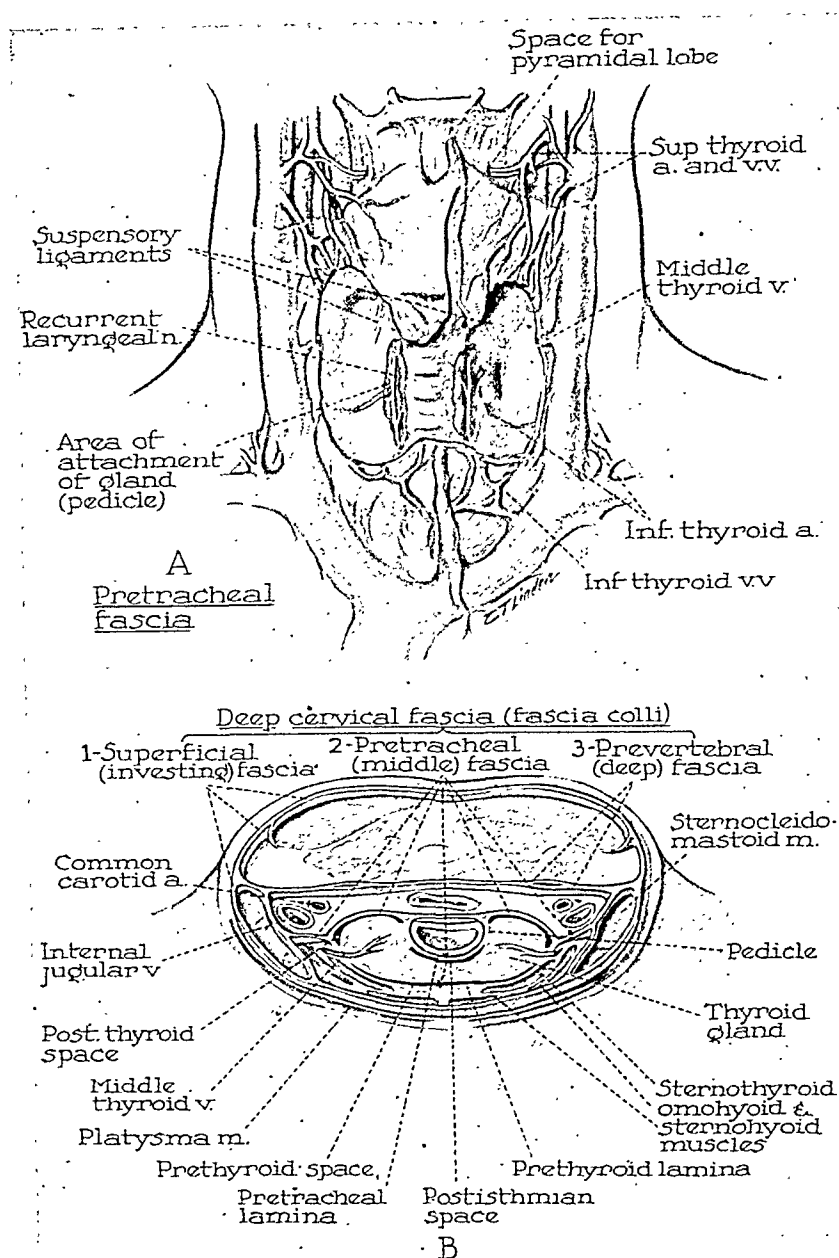


FIG. 1. A, the suspensory ligaments of the thyroid gland are shown passing from the inner margins of the gland to the cartilaginous framework. The vessels and recurrent laryngeal nerve as related to the pretracheal fascia are demonstrated. B, the deep cervical fascia (fascia colli) in cross section. This fascia consists of three layers: superficial (investing), middle (pretracheal) and deep (prevertebral). The important pre- and post-thyroid spaces are shown as related to the middle thyroid vein.

the postero-lateral border of each lateral lobe from the superior thyroid vessels to the lower pole.

The pretracheal lamina proper of pretracheal fascia extends medially passing behind the thyroid lobe, the lateral border of the esophagus and the trachea. At this point it thickens to form the pedicle of the

thyroid gland. These anterior and posterior laminae do form a sheath but the fixations of the sheath to the gland must be understood if proper mobilization is to be effected. The fixation of the gland in the region of the pedicle is firm, hence, no cleavage plane exists. From this pedicle the fascia extends medially over the tra-

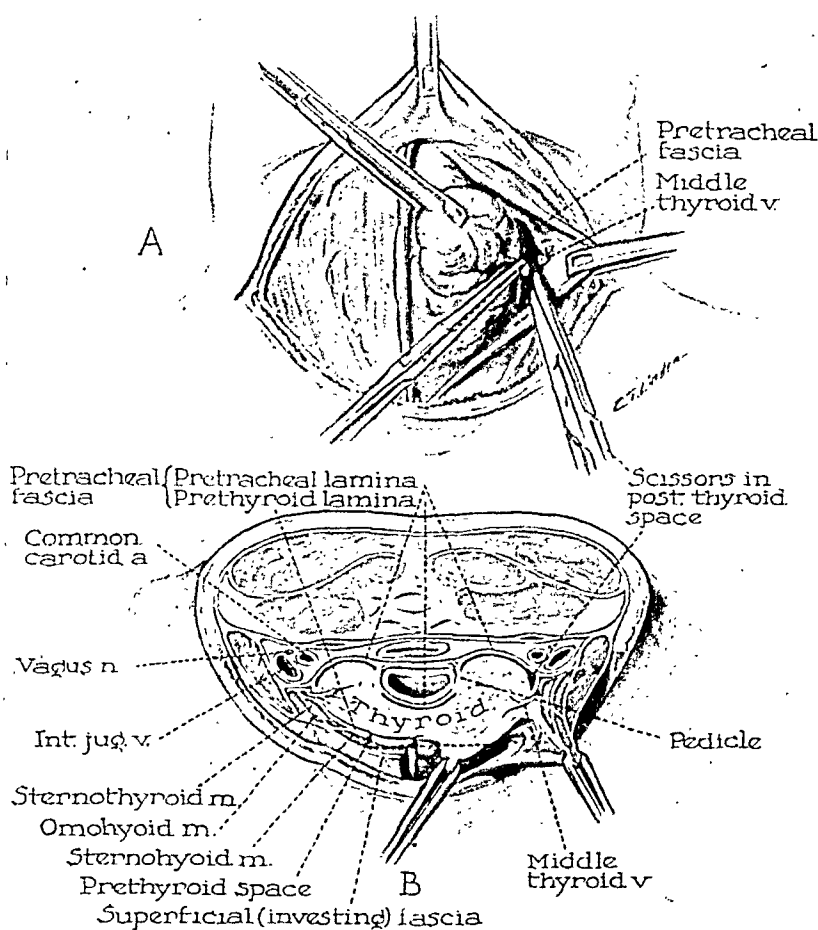


FIG. 2. A, the middle thyroid vein as it passes in the pretracheal fascia has been severed and ligated. By so doing the post-thyroid space is entered and the thyroid lobe can be properly mobilized. B, the two laminae (prethyroid and pretracheal) of pretracheal fascia are diagrammatically shown. To the reader's right the prethyroid space has been entered; the middle thyroid vein separates this from the post-thyroid space. The prethyroid space is entered as soon as the fascia which lines the posterior surface of the sternothyroid and the areolar tissue which forms a sheath for the thyroid gland is incised; the latter two are usually intimately related. The post-thyroid space is entered when the middle thyroid vein is severed and the lateral attachment of the pretracheal fascia to the lateral border of the thyroid lobe is incised.

chea and larynx to become continuous with the same layer of fascia from the other side. Some of its more posterior fibers blend with the buccopharyngeal fascia. Anterior to the pedicle the fascia becomes separated by areolar tissue so that immediately behind the thyroid isthmus and pyramidal lobe a definite cleavage plane is found.

The suspensory ligaments of the thyroid gland are thickenings of the pretracheal fascia which pass from the inner margins of the gland to the cartilaginous framework. (Fig. 1A.) These two ligaments, right

and left, form a sling which anchors the gland to the larynx; they must be severed before the gland can be properly mobilized. In large goiters they increase in size and prevent the thyroid from falling away from the larynx.

The structures which are found between the layers of the pretracheal fascia are the vessels which enter and leave the gland. (Fig. 1A.) The superior thyroid vessels are located between the pretracheal and prethyroid laminae. The inferior thyroid artery emerges from behind the carotid

sheath, penetrates the posterior aspect of the pretracheal fascia and passes medially to the pedicle of the gland where it usually divides into two or more branches. The inferior thyroid veins and the ima vessels are situated inferiorly between the prethyroid and pretracheal laminae. The parathyroids, external and recurrent laryngeal nerves and the thymus are situated in different morphologic planes from the thyroid gland and, therefore, lie outside of the fascial investments which have to do with the gland proper. This latter fact was demonstrated by Weller<sup>4</sup> in as early a stage of development as the 20 mm. embryo. The structure of great surgical importance in the prethyroid lamina is the middle thyroid vein. This vessel, although inconstant, usually leaves the gland about its middle, follows the inferior border of the omohyoid muscle across the carotid artery and ends in the internal jugular vein.

The vertical extent of the pretracheal layer of deep cervical fascia extends from the hyoid bone above to the fibrous pericardium over the great vessels in the superior mediastinum below; it blends with the latter. This layer, therefore, forms a sheet or plate as it passes in front of the larynx and carotid system rather than a circular tubing as is formed by the superficial or investing layer of deep cervical fascia.

*Prevertebral Layer.* The prevertebral layer of deep cervical fascia is of no practical importance in thyroid surgery. Therefore, it is sufficient to state that it is horizontally placed and is an offshoot from the deep surface of the sternomastoid muscle. It passes behind the carotid system, pharynx and esophagus but in front of the prevertebral muscles and vertebrae. Vertically, it extends from the base of the skull above to the posterior wall of the superior mediastinum below.

#### SURGICAL CONSIDERATIONS

Proper exposure and mobilization of the gland are the two absolute prerequisites for the completion of a successful thyroid-

ectomy. Therefore, certain steps in the operative procedure must be emphasized.

The sternothyroid muscle is considered the key structure in locating the so-called "prethyroid space." A distinct anatomic interval or plane is present between the sternohyoid and the more deeply placed sternothyroid muscles. After entering this plane the operator either can retract the sternohyoid muscle or sever it transversely at a high level, thus avoiding its nerve supply (ansa hypoglossi). The sternothyroid muscle is then identified, exposed and retracted or transversely severed. As a result of this last maneuver the fascia (prethyroid lamina of pretracheal fascia), which surrounds this muscle and is intimately related to the areolar tissue which forms the sheath of the gland, is incised and the prethyroid space is entered. Although the sheath has been severed and the proper cleavage plane entered, the gland, nevertheless, cannot be mobilized because of the lateral attachment of the pretracheal fascia to the thyroid lobe. It is more accurate to state, therefore, that after severing the sternothyroid muscle and its fascia the surgeon enters the prethyroid space.

Entrance into the post-thyroid space is accomplished by separating the prethyroid fascia from the lateral surface of the lateral thyroid lobe. Since the middle thyroid vein runs in this fascia it becomes a practical maneuver to identify this vessel, sever and ligate it. By so doing, a communication is established between pre- and post-thyroid spaces. (Fig. 2A.) The post-thyroid space having been entered, the gland can be properly mobilized and its posterior attachments by its true pedicle are easily identified.

Poate<sup>5</sup> states that as long as one is within the proper fascial planes and severs the vascular connections of the gland, the important nerves and parathyroids remain uninjured.

Once these maneuvers have been accomplished and the gland properly mobilized, any routine of technic which the surgeon has become accustomed to will suffice. In

the technic described by Warren H. Cole<sup>6</sup> the upper pole is first isolated, clamped and doubly tied. The lobe is then rolled forward and the remaining attachment of the upper pole is clamped and severed. The inferior vascular attachments and ima vessels are ligated and dissection is carried toward the midline exposing a small section of trachea. Routine removal of the gland by clamp and cut method is then instituted.

#### SUMMARY

1. Numerous dissections performed in both operating room and dissecting room have shown that the idea of a so-called thyroid capsule or sheath which completely surrounds the thyroid gland without any connections is morphologically and surgically incorrect.

2. Two distinct cleavage planes exist which are identified as pre- and post-thyroid spaces.

3. The prethyroid space or plane is entered as soon as the fascia which lines the posterior surface of the sternothyroid muscle and the areolar tissue which forms

the thyroid sheath is incised. The latter two usually are intimately related.

4. The post-thyroid space is a triangular interval which is entered when the middle thyroid vein is severed and the lateral attachment of the pretracheal fascia to the lateral border of the thyroid lobe is incised.

5. A thorough understanding of the deep cervical fascia and its simple arrangement into three layers enables one to utilize true fascial planes in thyroid surgery rather than attempting to demonstrate and enter a complete encircling capsule or sheath which does not exist.

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# INSTRUMENT FOR PRECISE FORMATION OF THE TUBE GRAFT AND FRENCH FLAP\*

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THE French or sliding graft, single or double, and the tube graft are used in the repair of certain skin defects. Illustrated herein are a number of diagrams demonstrating their formation and uses. It will be noted that geometric accuracy prevails throughout and that all parts slide snugly into place. (Fig. 1.)

In actual surgical practice such geometric perfection is difficult to obtain with the single blade due to the inherent elasticity and retractibility of the skin. However, with the aid of this instrument, such correctness can be secured readily. Marking the skin with colored guide lines or scratching the outline of the proposed incisions with a knife is eliminated and the required flaps are far more accurate than any obtained by any previous method. Added to this is the advantage that in those cases in which the flaps must be lengthened at a later stage we have a means available to do so and to be certain that the added skin flaps are of the exact measurements as those done previously. (Figs. 2 and 3.)

*Method of Use.* The desired knife blades are inserted and the distance between the blades adjusted. The instrument is held by the bars and drawn firmly through the tissues. Using one blade as a fulcrum, a circular incision may be made.

## ADVANTAGES AND USES

1. Parallel incisions through the skin can be made in any width for any length.
2. The centimeter scale permits later reproduction of the original pattern if required.
3. The instrument will adjust from 0.5 cm. to 10 cm.

4. For the double French flap, accuracy is assured that both flaps will be of equal width.

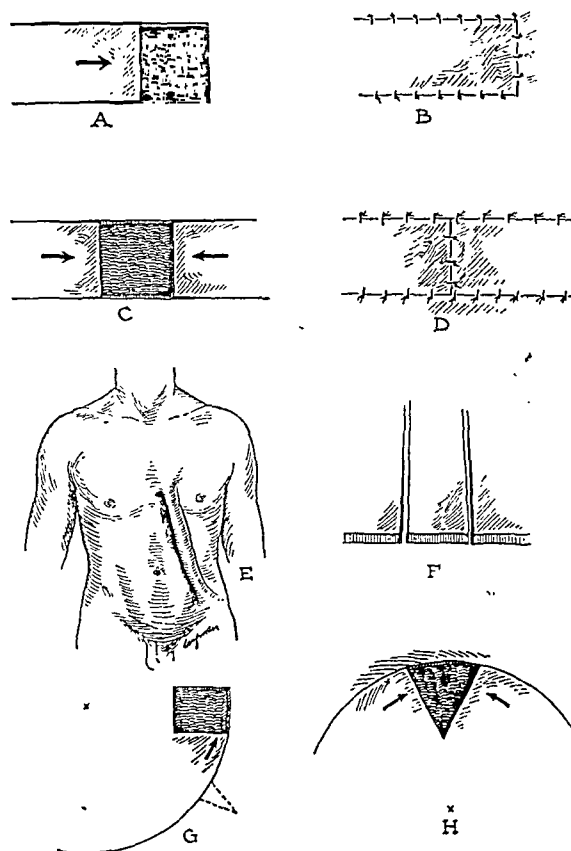


FIG. 1. A, single French (sliding) flap; B, double French flap; C, long tube graft; D, demonstration of accurate surgery possible with double-bladed knife; E and H, demonstration of skin defects closed with circular incisions.

5. A geometrically precise tube graft of any size can be made in any part of the body.
6. With one knife blade as a pivot, curved flaps may be formed and circular incisions made.

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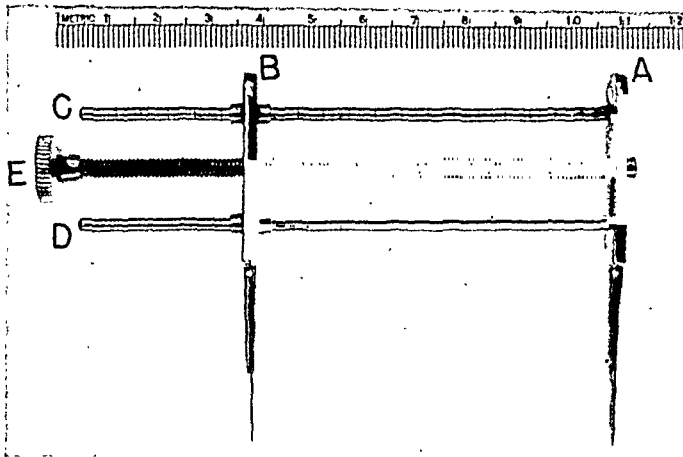


FIG. 2

FIG. 2. A and B, knife blades; C, calibrated bar for measuring purposes; D, stabilizing bar; E, curled knob and long screw for adjusting knife blades.

FIG. 3. Angle view to show details of construction.

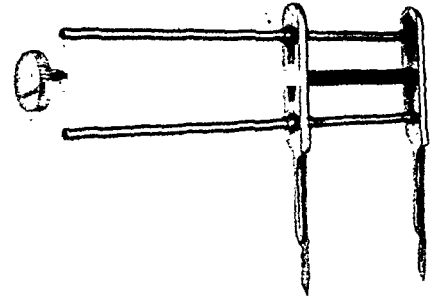


FIG. 3

7. All incisions are made at right angles to the skin. There is no bevelling of the skin edges.

8. The operative procedure is shortened.

#### SUMMARY

This instrument has been used in several selected cases. It is presented as a useful

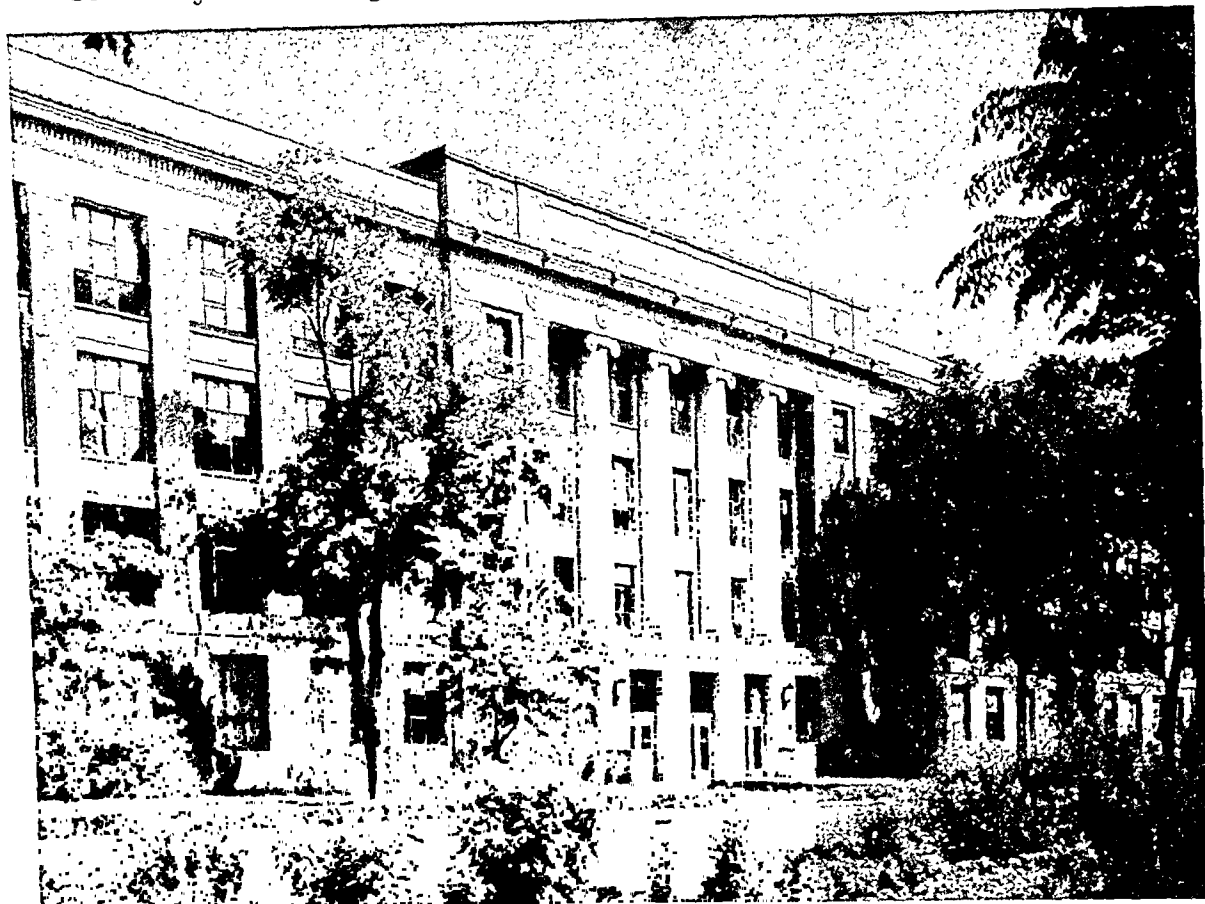
addition to the armamentarium of the plastic surgeon. It is hoped that it will facilitate procedures hitherto considered difficult for the plastic repair of certain skin defects and the treatment of specific lesions. With precision flaps available, better cosmetic results will be obtained.



# UNIVERSITY OF MICHIGAN MEDICAL SCHOOL

*Ann Arbor, Michigan*

THE Medical School was the first professional school established in the University of Michigan. Provision attended two full courses of lectures and to have spent one year with a practitioner. In 1878 the curriculum was extended to



University of Michigan Medical School—East Building

was made for it in the legislative act of 1837, by which the University was organized in its present form, and it was opened for students in 1850.

During the first two years of its existence the annual course of lectures was begun on the first Wednesday of October and continued until the third Wednesday in April. In the third year the commencement was held on the first Wednesday in April and, for the next four years, on the last Thursday in March. From 1858 to 1878 it came on the last Wednesday in March. The candidate for a degree was required to have

two years of nine months each and in 1880 three such years of study became necessary before a candidate could present himself for final examination. In 1890 the compulsory term of study was extended from three years to four. The three years of nine months each had allowed a graded curriculum to be established; the addition of a fourth year permitted further gradation and gave opportunity for the extension of laboratory teaching. The main features of the curriculum in operation since that date have been sequence and concentration in the subjects presented, abundant labora-



tory teaching and a general survey of each branch by means of lectures, recitations and demonstrations. A combined curriculum in letters and medicine was provided in 1890 and graduate courses were offered.

The Medical Library of the University of Michigan now numbers 73,863 volumes. Five hundred thirty-three of the best current medical journals in English, French, German, Italian and Spanish are regularly taken. The Library is essentially one of medical reference and has become a very complete reference library for modern medicine. The volumes contained in it give practically the complete evolution of modern pathology, experimental physiology and pharmacology, bacteriology, serology, immunology, practical hygiene, anatomy and experimental medicine and surgery of the last hundred years. In addition to the volumes contained in this library there is a

large amount of medical material available in other departmental libraries and the General Library. Were the entire medical material of all the libraries belonging to the University collected in one library, the medical collection of the University of Michigan would rank in size and importance among the foremost libraries of the United States. As it is at present it holds the rank of the most important reference medical library directly connected with any medical school.

The University Hospital with a capacity of 981 beds is essentially a teaching hospital under the control of the Board of Regents of the University of Michigan. The medical affairs of the Hospital are so managed as to ensure the most thorough utilization for instruction and research of the treatment of patients.



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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-eighth Year of Publication

VOL. LXXVIII

AUGUST, 1949

NUMBER TWO

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## Editorial

### THE FACTS

THE other day we received in the mail a sixteen-page folder issued by The American Medical Association entitled "The Voluntary Way is the American Way." This pamphlet contained fifty questions and answers on Compulsory Health Insurance versus Health—the American Way. No doubt you, too, received this pamphlet. If not, the following few selected questions and answers will give an idea of what physicians should know about this subject. Should you wish this story of compulsory health insurance versus voluntary health insurance in full, you may send for a copy to The American Medical Association, 1 North La Salle Building, Chicago, Illinois.

Q. What is "Compulsory Health Insurance"?

A. It is a multi-billion dollar program proposed by the office of the Federal Security Administrator, which would supplant Voluntary Health Insurance with Compulsory Health Insurance—levying a payroll tax to support the new Government-regulated system of medicine.

Q. Why is it proposed at this time?

A. Government advocates argue that low standards of public health and medical care in America today make Government control imperative.

Q. Is it true that America has "low grade" health care?

A. No. Among all the great Nations, the highest standards the world has ever known in medical care and scientific progress, both in reducing disease and lengthening life—are *here in America*.

Q. Who is for Compulsory Health Insurance?

A. The Federal Security Administration.  
The President.

All who seriously believe in a Socialistic State.

Every left-wing organization in America. Two specially organized propaganda groups—the "Committee for the Nation's Health" and the "Physicians Forum"—whose prime concern is campaigning for Compulsory Health Insurance. (Most rank-and-file union men are violently opposed to more payroll deductions.)

The Communist Party.

Q. What is "compulsory" about Compulsory Health Insurance?

A. The payroll tax is compulsory. There is no escape from it. But there is no compulsion on Government to maintain standards or fulfill promises. That's the joker!

Q. Will people who don't wish to use the Government service have to pay the tax?

A. Yes. Everybody with a paycheck or an income will pay the tax, whether he uses the service or not.

Q. Will veterans who already have paid for medical care by their war service, be taxed?

A. Yes. Veterans will pay the tax, even though they don't need the service and don't want it.

Q. Will members of faith healing religions be taxed?

A. Yes. Millions of members of all faiths whose principles would prevent use of the service, nevertheless will be taxed for it.

Q. Will people who already are protected under satisfactory Voluntary Health Plans be taxed?

A. Yes. Whether protected under medical care Plans, commercial, industrial, fraternal, or labor Plans, they will be compelled to pay the tax for the Government Plan.

Q. How much will the tax be?

A. Sponsors have used various figures. Estimates range from 3% to 10% on every paycheck up to \$4800, half paid by the employe and half by the employer. The self-employed would pay the whole amount.

Q. What does that make the total bill?

A. The medical bill of the average family would be doubled, if not trebled. The staggering cost to the Nation has been estimated at from 6 to 15 billion dollars.

Q. Why don't the sponsors advise the people honestly and clearly on this all-important matter of cost?

A. They know they are apt to be wrong however well they figure. No Nation which has tried Government-controlled medicine ever has been able to anticipate the cost correctly. In New Zealand, the cost multiplied eight times in five years. In England Government medicine has gone 200 million dollars in the red in the past nine months, grossly exceeding estimates first given the people.

*And the type of assembly-line service being rendered there would not be tolerated by Americans!*

Q. Why should the cost, even for second-rate service, run so high?

A. *Because Government-controlled medicine is political medicine!*

In Germany it took one Government employe for every 100 persons insured. At that ratio, America *would require a million and a half non-medical employes—clerks, administrators, bookkeepers and tax-collectors—on the Federal payroll, siphoning off medical funds before they ever bought the patient care of any kind.*

Q. Is Compulsory Health Insurance really "insurance"?

A. It is not. And it is gravely unfair to the people to pretend that it is.

Reasons it is not "insurance":

1. Though an arbitrary "premium" is collected, in the form of a payroll deduction, *benefits are neither specified nor guaranteed.*

In the exact language of the sponsors, certain services are promised "when funds are available," "insofar as possible," and "when facilities permit"!

2. Sound insurance is based on sound actuarial standards—and on contracts clearly setting forth both benefits and costs. Millions of Americans have such guarantees in writing—under Voluntary Health Insurance.

*But the only guarantee in the Compulsory Health "Insurance" proposal is guarantee of a new payroll tax—the amount unpredictable!*

Q. Did the National Health Assembly recommend Compulsory Health Insurance?

A. No. After a meeting of the National Health Assembly, the office of the Federal Security Administrator submitted to the President a "Report on the Nation's Health" and a "Ten Year Program." These are the personal reports and recommendations of a Federal office holder. The Assembly refused to recommend Compulsory Health Insurance.

Q. Would socialized medicine lead to socialization of other phases of American life?

A. Lenin thought so. He declared: "Socialized medicine is the keystone to the arch of the Socialist State."

Today, much of the world has launched out on that road. If the medical profession should be socialized because people need doctors, why not the milk industry?

Certainly, more people need milk every day than need doctors.

On the same erroneous premise, why not the corner grocery? Adequate diet is the very basis of good health!

Why not nationalize lawyers, miners, businessmen, farmers? Germany did, Russia did. England is in the process.

Q. What does this prove?

A. *It proves that America is the last great free Nation on earth!*

It is strong and productive and virile enough today, under its own system, to shoulder the burdens of the rest of the world!

*It proves that the greatest error in all history would be for America to start borrowing the unsuccessful systems of foreign countries which today are on their feet only because the American system is strong enough to support them!*

Q. How do movements like Compulsory Health Insurance get started?

A. Because people of short memory for American history, and shorter vision for the American future, proclaim that increasing political control of American lives and work is a "trend." *It is a trend only so long as energetic people who like the American way of life above all others, look the other way when political controls like "Compulsory Health Insurance" are proposed!*

Q. Where did Compulsory Health Insurance start?

A. Germany had the first and strongest all-inclusive program.  
*If the world needs proof of what regimentation and political domination of doctors and scientists can do, even in this modern world—the Nueremburg Trials have supplied it.* The medical men of Germany, once honored for their humanitarian progress, have not yet been admitted back into the World Medical Society.

Q. Why do doctors generally oppose Compulsory Health Insurance?

A. Because it is compulsory regimentation, and because the historical record of every great country to try politically-controlled medicine, is a record of

Deterioration of medical education, training and research.

Degeneration of medical standards, and of medical care.

Steady decline of the people's health.

Q. Why does medical care suffer under political medicine?

A. Because doctors are responsible to politicians first—and their patients, second. They are overwhelmed with paperwork and red tape.

They are swamped with patients who do not need care, as well as those who do.

In England today, for example, many physicians are seeing as many as 80 patients in the four hours of office practice, according to the authority of Elizabeth Wilson, American writer and actuary who has studied the British system first-hand. That permits about three minutes per patient for diagnosis and treatment! Such a system would scarcely suit Americans!

Q. Why are some prominent British visitors here reluctant to comment on how socialized medicine is working in England?

A. Criticism of their Socialist Government would jeopardize American loans to that Government. Every thinking American is aware of this.

Q. To the average family, are medical bills the biggest problem?

A. No. The most critical problem in the average household today is not the medical bill, but the tax bill!

*Medical care costs the average American family about 4% of income, according to the Brookings Institution. But tax bills take from 20 to 30 per cent of family income!*

If the unreasonable costs of Government were reduced, the American people could afford better health standards—better food and better housing. But Compulsory Health Insurance would add to the burden, rather than relieving it!

Q. Is it true that "Health Insurance is Coming"?

A. It is here. The only question is: How will you have it? On a *voluntary* basis with doctors in charge—or on a *compulsory* basis with politicians in control?

Q. Has Voluntary Health Insurance been tried extensively?

A. Yes. Doctors discovered long ago that most families need some means of cushioning the economic shock of sudden illness or accident. State Medical Societies started studying, approving and initiating sound non-profit Medical Care Plans over a decade ago. Hospital plans—and insurance company plans—also are operating successfully in every section of the country. Today, Voluntary Plans are providing budget-basis hospital, medical and surgical care for millions.

Q. What has the experience proved?

A. *That there is nothing Government can do in the field of Health Insurance which the private citizen can't do better for himself—and at far less cost!*

Q. How many people are protected under Voluntary Health Insurance?

A. More than 55 millions are protected under hospital, surgical or Medical Care Plans. *That is more than a third of the entire population, budgeting its own health protection!*

#### *Compulsory Health Insurance Means:*

Second-rate medical care.  
Decline of medical education, training, research.  
Invasion of personal privacy in medical matters.  
Political control of medical systems.  
A growing political hierarchy of Government administrators.  
Constantly mounting payroll taxes.  
Extension of controls over other professions.

*One standardized brand of medicine for America  
—the Government-controlled brand.*

#### *Voluntary Health Insurance Means:*

Guaranteed protection from financial shock in time of illness.  
*High quality medical care, free from political red tape or interference.*  
Low budget-basis cost and certain knowledge of the costs.  
Absolute guarantee of the benefits.  
Free choice of service.  
Free choice of doctor.  
Freedom from new payroll taxes.  
Privacy in personal medical affairs.  
The right to spend the medical dollar as desired.  
Maintenance in America of the world's highest medical standards.

Just before we started this "abstract and paste-up" job, we read an A. P. Washington dispatch. It said that the United States Chamber of Commerce disputed the administration's argument that compulsory health insurance is needed because most Americans cannot afford doctor bills.

"In 1947," the Chamber said, "the American people spent \$10,000,000,000 for liquor, \$4,000,000,000 for tobacco and over \$2,000,000,000 for cosmetic items—to mention only a few non-essentials. In the same year they spent \$1,700,000,000 for physicians' services."

Our nation's health is better than ever before and compares favorably with that of any other nation. Let us keep it that way.

T. S. W.



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# Original Articles

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## NEW HORIZONS IN THE SURGICAL MANAGEMENT OF CARCINOMA OF THE PROSTATE GLAND\*

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THIS presentation is a preliminary report based on clinical observations and experiences gained during the study of over 100 consecutive cases of primary cancer of the prostate including a detailed description of some of the fourteen patients operated upon since the introduction of hormone therapy.<sup>1</sup> These illustrative cases are of clinical and pathologic interest and give some idea of the new horizons in the treatment of cancer of the prostate which promise to multiply the percentage of permanent cures. However, it is obvious that this series of cases is too small and that insufficient time has elapsed to permit any final conclusions as to the worth of the method reported herein. Nevertheless, I feel justified in reporting my work and observation at this time since hitherto unattainable striking results are obtainable by this new approach.

Since indications for radical perineal prostatectomy for carcinoma of the prostate before the era of hormone therapy were limited to about 10 per cent of cases, due to either extension of the disease or to technical inoperability, not more than a decade ago we<sup>2</sup> advocated transurethral resection in 90 per cent of cases merely for the relief of obstructing symptoms. The possibilities of cure were very remote in any of the groups. More recently the work of Huggins and his co-workers intro-

ducing orchiectomy,<sup>3</sup> Munger's sterilization by deep x-ray therapy<sup>4</sup> and the use of estrogens to control the disease<sup>5</sup> have resulted in palliation and notable amelioration of symptoms; but none of these new measures have yielded five-year cures in this distressing malady. It appears, therefore, that a new approach to this unsolved problem is justified.

Up to the present time as many as 90 per cent of patients coming for treatment for carcinoma of the prostate gland arrive too late for cure because the cancer has progressed to a stage where its radical removal is no longer possible. Until recently all that could be offered were various palliative measures for the relief of pain and urinary obstruction. After a respite of one to three years, however, their symptoms recur and the malignant tumor, still present in its original site, resumes its growth, metastases develop and the patient inevitably dies. It is now generally admitted that any treatment except radical surgical removal of cancer is purely palliative and not curative.

With the advances made in the past decade in the palliative hormone treatment of this disease, and following its scientific and clinical application, a new outlook also for curative therapy (in other words for the only known curative method, radical perineal prostatectomy) begins to dawn.

\* Read before the Clinical Meeting of the Wickersham Hospital, New York, December 18, 1947. Also presented before the Argentine Urological Association in Buenos Aires, Argentina, August 13, 1948, and other urologic societies of South America.

I have become increasingly convinced that a radical perineal prostatectomy performed at the time of maximum retrogression of the tumor under the influence of hormone therapy<sup>1</sup> may save the lives of a considerable group of patients hitherto doomed to die of cancer. Recently Colston and others have published cases in which they were able to do a radical operation owing to changes produced in the tissues by the use of diethylstilbestrol or by castration.<sup>6-8</sup>

The historical development of the surgical management of prostatic cancer since its first recognition by Albarran<sup>9</sup> may be tabulated as follows:

#### Evolution of Treatment for Cancer of the Prostate

##### *Prior to 1895:*

No knowledge of cancer of the prostate  
No differentiation from benign hypertrophy

##### *Albarran Period 1895-1900:*

Clinical and histologic recognition of cancer of the prostate  
Dawn of surgical era

##### *Early Methods:*

Castration  
Ligation of the vas deferens  
Bottini's galvanocautery operation  
Perineal prostatectomy  
Suprapubic prostatectomy

##### *Later Methods:*

Radium and deep x-ray therapy  
Permanent cystostomy  
Transurethral prostatic resection  
Castration or orchiectomy  
Hormone therapy

##### *Author's Method:*

Total, subtotal or *radical perineal prostatectomy*, as indicated following preliminary hormone therapy.

The only hope for curative treatment in cancer of the prostate gland is radical perineal prostatectomy, which is known to salvage about 50 per cent of the patients. The great stumbling block to date has been that only some 10 per cent of the patients arrive for treatment at a time when the

tumor is still operable. (Fig. 1.) Alcock and others<sup>10-12</sup> have even suggested that radical perineal prostatectomy be discarded as a basic treatment for cancer of the prostate just because of this narrow field of applicability. So far, the only means suggested to overcome this stumbling block has been an attempt to bring these patients for earlier diagnosis by the institution of periodic examinations of the prostate gland in all men over forty years of age.

In my opinion, however, there is another method of increasing the number of cases amenable to operation. It must be interpolated here that scirrhus carcinoma of the prostate can never be cured by any operation however radical, but adenocarcinoma, even if inoperable on admission of the patient, may under the influence of hormone therapy become so transformed as to render operation possible.

#### CLINICO-PATHOLOGIC CLASSIFICATION AS AFFECTING OPERABILITY OF CARCINOMA OF THE PROSTATE

The decision to perform a radical operation for removal of carcinoma of the prostate gland depends primarily on the recognition of the two types of carcinoma encountered in this organ, namely, adenocarcinoma and scirrhus carcinoma.

Adenocarcinoma is the most common type and offers the best prognosis. In this type the response to hormone therapy is ideal and cases which appear technically inoperable on admission can be rendered operable by judicious hormone therapy. In many cases of adenocarcinoma the malignant process may have extended beyond the capsule occasionally involving not only the seminal vesicles but showing nodules and infiltration of the posterior as well as the two lateral lobes. Even in such cases hormone treatment may render the patient amenable to radical perineal prostatectomy, with a chance of cure.

Scirrhus carcinoma represents approximately 20 per cent of all cases. In this form of malignancy the gland, instead of becoming larger as in adenocarcinoma,

shrinks to a stony hardness and becomes fixed and immovable, the cancer finally infiltrating all elements of the gland and expanding beyond the capsule. In this type bony metastases form early and are usually present when the patient is first seen. There

of the prostate gland are inoperable. The treatment indicated is a purely palliative transurethral resection to relieve urinary obstruction when necessary.

It is imperative, therefore, to distinguish clinically between adenocarcinoma and

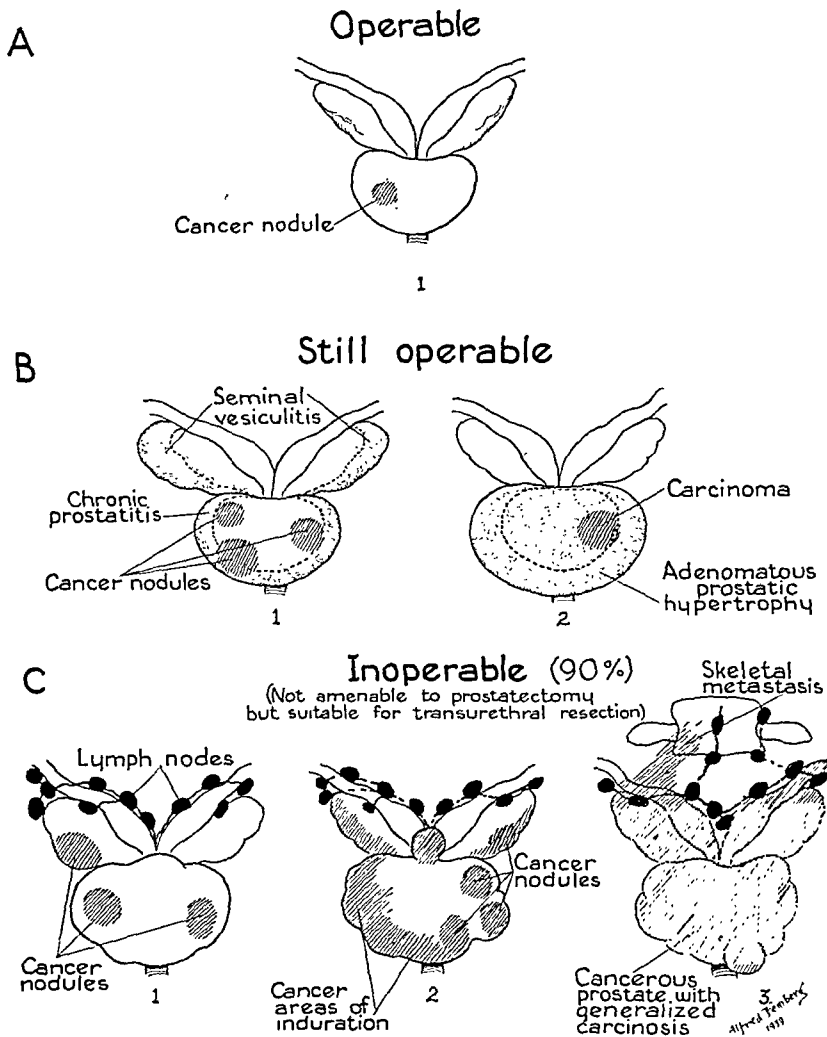


FIG. 1. Schematic drawing (from GUTIERREZ, R. *Am. J. Surg.*, 68: 330, 1940) representing in A and B the various clinical types of early carcinoma of the prostate which, before the era of hormone therapy, were amenable to radical perineal prostatectomy; in all, about 10 per cent of cases. C illustrates the various types of advanced carcinoma of the prostate in which the lesion had extended beyond the capsule of the gland and which were therefore considered inoperable. However, at present because of the metamorphosis of the cancer and relief of symptoms which can be attained by preliminary hormone therapy, operability has been extended so that instead of the former 80 to 90 per cent incidence of inoperability, a radical perineal prostatectomy, with its 50 per cent possibility of cure, can now be applied in more than half of the patients reporting for treatment.

is no response to hormone therapy since there is no normal glandular tissue left to respond. Carcinosis, or diffuse prostatic pelvic carcinoma, and scirrhous carcinoma

scirrhous carcinoma of the prostate gland because the two groups present different surgical indications. If the patient with adenocarcinoma responds favorably to



hormone therapy in a period of four to eight weeks or to castration with resultant softening and shrinking of the gland, he should be subjected without delay to a radical perineal prostatectomy for removal of the growth and cure of his primary ailment. This is the only treatment which offers hope of permanent cure.

*Symptoms and Signs of Carcinoma of the Prostate.* In the earliest stages of the disease carcinoma of the prostate is asymptomatic. The course of the disease is insidious and progressive, beginning, as a rule, in the subcapsular region of the posterior lobe of the gland. It is only during systematic general physical examination that rectal palpation reveals a hard nodule which suggests the presence of carcinoma. As the disease progresses, urinary symptoms will develop including diurnal and nocturnal frequency, dysuria, painful micturition and occasionally slight sexual disturbances such as impotence or weak sexual power either alone or associated with the urinary symptoms. The history of these patients will in many instances reveal attacks of sciatic pain, lumbago, rheumatoid arthritis or pain in the gluteal regions or lower part of the back radiating to the legs. The pain may be distributed also in the bladder, urethra, rectum, perineum, sacrum or inguinal or scrotal regions. Such a history in a man over fifty years of age should suggest the possible presence of carcinoma of the prostate gland.

In more advanced cases and particularly in adenocarcinoma of the prostate urinary symptoms become more marked and may include, besides those previously mentioned, intermittent attacks of complete retention, bladder tenesmus, difficulty in urination and occasionally hematuria and pyuria, particularly if there is obstruction at the vesical outlet with residual urine. All of these symptoms may, however, be present in benign adenomatous hypertrophy of the prostate gland but on rectal palpation the latter can be recognized by its smooth elastic surface while adenocarcinoma presents a hard, nodular, irregu-

lar surface not unlike that of the knuckles of the hand. Biopsy, x-ray and urographic examinations will be required for differential diagnosis.

Besides the early asymptomatic cases there are also advanced cases which are asymptomatic or silent. In these the true condition may be discovered accidentally during roentgen examination for general diagnostic purposes by shadows in the lumbosacral or pelvic region, indicating bony metastases from a primary malignant focus in the prostate gland which may have developed to the point of metastasizing without having caused urinary obstruction. Rectal and bladder symptoms are not uncommon. Many patients in the advanced group complain of suprapubic and perineal pain, rectal itching, constipation and hemorrhoids as well as arthritis, anemia, weakness and loss of weight.

*Diagnosis of Carcinoma of the Prostate Gland.* The clinical diagnosis of carcinoma of the prostate gland is made by rectal palpation with the experienced examining finger. Adenocarcinoma is a symmetrical enlargement of the gland of the trilobar type and the hypertrophy involves all elements of the parenchyma. The surface is smooth and leathery in consistency and the gland is uniformly enlarged with one or two palpable hard nodules. Sometimes there is marked induration of the posterior or lateral lobes which may extend into the seminal vesicles, whereas in scirrhous carcinoma the gland is reduced in size and is of a stony hardness with multiple hard nodules, an irregular surface and fixed. The diagnosis is more obvious when palpation of the gland is made against a metal sound placed in the urethra, which facilitates differential diagnosis from prostatic calculi. These two conditions, however, have been known to coexist.<sup>13</sup> The clinical and differential diagnosis can be confirmed by biopsy and by a demonstration of a rise in serum acid phosphatase as well as by the metamorphosis observed in the cancerous gland after the administration of hormone therapy.

There are several approved methods of removing specimens from the prostate gland for microscopic or histologic sections. The expert pathologist can make his diagnosis after examination of several frozen sections.<sup>14</sup> Biopsy specimens may be obtained by perineal needle aspiration, rectal trochar punch or by transurethral resection.<sup>15</sup> The latter does not always yield reliable results because the resected portion is limited to the median and two lateral lobes and no tissue is taken from the posterior lobe which is most frequently the site of the primary lesion (Case ix). The most accurate and reliable biopsy is made by perineal exposure of the prostate at the time of operation when a suitable piece can be sectioned under direct vision and sent to the pathologist for frozen sections. However, minor foci of cancer of the prostate involving only minute areas of the medullary portion of the gland are common (found in 18 to 21 per cent of patients dying from prostatic obstruction); these can be located by complete histopathologic section of the whole specimen removed at operation or postmortem.<sup>16,31</sup> Biopsy specimens also serve for histologic differentiation of the two types of prostatic carcinoma.

Recently the Papanicolau smear method,<sup>17</sup> used so successfully with vaginal smears in the diagnosis of cancer of the female cervix, has also been applied to cancer of the prostate. Repeated examinations of the urine and of prostatic secretions obtained by vigorous massage will reveal the presence of cancer in the prostate in many instances.

The information obtained from a careful clinical history of the patient and a complete urologic examination will usually suffice for preoperative diagnosis and selection of patients suitable for total perineal prostatectomy. The complete urologic examination should include besides the findings in the rectal palpation of the gland and the seminal vesicles the estimation of the residual urine, cystoscopy, urethroscopy, x-ray, urograms, cystograms, evacuation

films of the cystogram and urethrocytograms. The routine examination for suspected malignancy should also include the usual laboratory tests showing the blood chemistry, blood count and the level of alkaline and acid phosphatase in the blood serum.

A certain diagnostic value also may be attached to an adverse effect of male hormone therapy in certain cases of benign hypertrophy of the prostate or impotence in which this treatment results in accelerated progression of symptoms and exacerbation of the local condition even to the point of producing atony of the bladder and inability to urinate, with an increase in the amount of residual urine and enlargement and stony hardness of the prostate.

#### PRELIMINARY HORMONE THERAPY IN PREPARATION FOR RADICAL PERINEAL PROSTATECTOMY

It is my conviction that the palliative effect of orchiectomy and hormone therapy, although a great boon in advanced malignancy or hopeless cases when such treatment may relieve suffering and prolong survival, is of infinitely less importance than their use in rendering *inoperable* cases *operable*. The patient can thus be prepared for radical curative surgery. As a preliminary treatment for preparing the patient for radical perineal prostatectomy, hormone therapy shows promise of increasing the percentage of operable cases from 10 to nearly 80 per cent. (Fig. 2.)

Castration, stilbestrol therapy and transurethral resection, which are definitely not curative, have been reserved for advanced stages of the disease until most recently. To be sure, now and again an isolated case may be caught at some critical stage of its development when castration or hormone therapy may suffice to check or control the malignant process as seen in Case i herein reported. However, such cases are exceptional rarities.

With the use of preliminary hormone preparation for radical surgery, a great new avenue of approach is opened to pa-

tients suffering from prostatic cancer. With the glandular metabolic dysfunction under control and shrinking and softening of the gland, the technically inoperable case becomes operable. In a selected group of patients responding temporarily to hormone

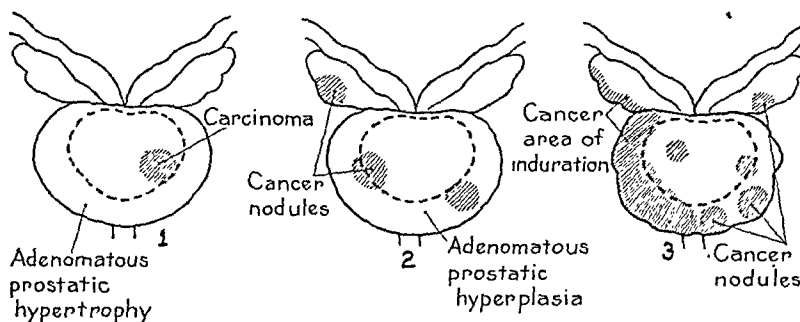
minish the size of the gland, render it soft and movable and, furthermore, produce regressive changes in the metastases and cancer cells themselves as has been proved by serial biopsies.

In choosing between these two methods

**A**

### OPERABLE (80 %)

(After hormone therapy)



**B**

### INOPERABLE (20 %)

(No response to hormone or castration)

(Not amenable to prostatectomy but suitable for transurethral resection)

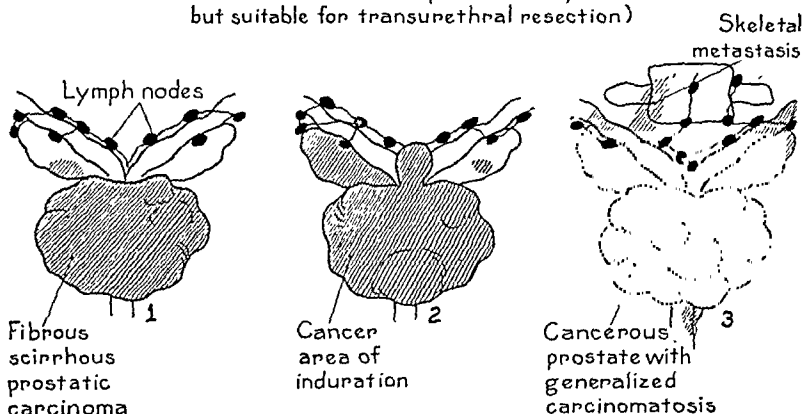


FIG. 2. Schematic drawing to illustrate the new horizons in the surgical management of carcinoma of the prostate gland. A illustrates the most common group rendered operable by the administration of hormone therapy and comprising about 80 per cent of cases (Cases I, II and III of the present series). In this group a cure by radical perineal prostatectomy can be attempted. B illustrates a second group of cases which do not respond to hormone therapy or castration sufficiently to permit perineal prostatectomy. In this scirrhus type of advanced cancer of the prostate, perineal prostatectomy is contraindicated except in rare instances but palliative transurethral resection for relief of symptoms due to obstruction is justifiable.

therapy the primary lesion can be removed, thus minimizing chances of recurrence and extension of the malignant process and affording the possibility of a permanent cure.

Both castration and the administration of diethylstilbestrol will relieve pain, di-

of hormone preparation of the patient for operation it must be taken into consideration that castration, besides being a more or less mutilating operation, involves the risk of engendering extragonadal production of androgens which may prove im-

possible to control. Furthermore, castration should be kept in reserve as a possible means of achieving results in cases which fail to respond to stilbestrol or become so saturated with it that it is no longer effective. Here castration has proved an added weapon. Cases may be encountered in which the efficacy of both castration and stilbestrol has been exhausted. In such cases the gland begins to harden again and to increase in size, metastases form with greater rapidity and pain and urinary obstruction recur. In these cases remarkable temporary improvement of symptoms and renewed retrogression of the carcinomatous process with shrinking and softening of the gland can still be obtained by the administration of progesterone, the corpus luteum hormone of the ovary, as was observed in Cases II, IV, VII and VIII herein reported.

Having concluded that the logical approach to preparation of the patient for radical operation is the administration of diethylstilbestrol, the hormone is given at first in very small doses so that the organism may become adjusted and tolerance increased. This is accomplished with a dose of  $\frac{1}{2}$  gr. of diethylstilbestrol three times daily for one month. In the next month dosage is increased to 1 gr. three times daily. In about two months the changes required to render operation practicable will have taken place. It is clear that with these small doses administered over so short a period of time, the usually encountered side effects of female sex hormone therapy such as hot flashes, gastric disturbances, swelling of the breasts, etc., may be avoided. The small dosage, however, does not interfere with the intended effects of hormone therapy and the patients enjoy relief from pain, diminished frequency of urination, reduction of the amount of residual urine and relief from other urinary symptoms (Case VII). Quite frequently metastases likewise begin to diminish in size and in some instances disappear altogether. During this period of preparation the patient naturally receives the benefit of all other methods designed

to increase resistance such as urinary antiseptics, bowel regulation, anti-anemics, a strengthening diet and indicated vitamins, particularly vitamin B complex. In this way the patient's strength is increased and he is better prepared to withstand the shock of operation and to overcome the toxic effects of the tumor products. By a routine urologic follow-up and careful observation of the serum acid phosphatase index the results of treatment can be evaluated. The serum acid phosphatase usually drops to normal shortly after onset of treatment. As soon as the disturbance in cellular metabolism is under control and the general condition of the patient has improved with the large, hard gland now softened and reduced in size, the patient no longer is considered a poor risk for radical intervention.

Once the patient has responded to hormone therapy to a degree rendering the radical perineal prostatectomy possible, further preoperative preparation will as a rule require a short period of hospitalization for drainage and routine functional tests. The following measures should be employed: (1) Retention catheter for drainage and continuous irrigation of the bladder must be used for a period of a week, ten days or two weeks or longer as may be required. (2) At the end of the first week all the laboratory tests, namely, blood count, blood chemistry and phenolsulfonphthalein tests should be repeated. (3) Daily intravenous infusion of 1,000 cc. saline and glucose 5 per cent must be employed for three or four days, or blood transfusions as indicated. (4) A well balanced diet with vitamin B complex, forced fluids and proper regulation of the bowels is essential. (5) Urinary antiseptics are administered in the form of combisul (sulfadiazine and sulfathiazole), or sulfonamides triplex, (sulfathiazole, sulfadiazine and sulfamerazine), penicillin and streptomycin as indicated. (6) Hormone therapy is increased during the preoperative hospitalization period and is administered in doses of 2 mg. orally three times a day

and 5 mg. daily by intramuscular injections (in all 11 mg. of stilbestrol daily).

The carcinoma is radically removed at the time of maximum improvement; thus there is far less chance of recurrence than there would be following the removal of only the obstructing portion of the gland as in transurethral resection. It is not unlikely that the metastatic foci, having responded to hormone therapy as frequently observed, may undergo still further regression once the primary tumor has been extirpated *in toto*. In fact it has been observed in certain cases of hypernephroma that after nephrectomy the pulmonary metastases have completely disappeared.<sup>18-20</sup> Therefore, it seems that the presence of metastases cannot always be considered a contraindication to radical operation. We have another vivid example of the curative effect of extirpation of the primary disease focus in tuberculosis of the kidney, when removal of the most seriously involved kidney frequently results in clearing up of the process in the other kidney and permanent cure.

Once the stage of optimum improvement by preliminary hormone therapy has been reached, the surgical procedure to be followed in the individual case will be determined by the extent of the malignant growth and the involvement of the contiguous structures as well as the general condition of the patient. The patient must, of course, meet the requirements of a sound criterion of operability.

#### TYPES OF OPERATION INDICATED FOR THE RADICAL CURE OF VARIOUS STAGES OF PROSTATIC CANCER

There are four types of radical perineal prostatectomy, each with its special indications as follows (Fig. 3):

*Type I.* When carcinoma is localized in the prostate, the gland and its capsule should be totally removed, with a subsequent plastic anastomosis of the membranous urethra to the vesical orifice.

*Type II.* When carcinoma of the prostate has involved the seminal vesicles, the

operation should be a complete prostatovesiculectomy followed by the same type of anastomosis as previously described.

*Type III.* When carcinoma of the prostate has involved the bladder neck, the operation should be the more radical procedure of removal of the prostate, the seminal vesicles and bladder neck followed by the same type of anastomosis of the membranous urethra to the remaining portion of the bladder.

*Type IV.* When carcinoma of the prostate has invaded the trigone, ureteral orifices or lateral walls of the bladder, the procedure should be the still more radical operation of transplantation of the ureters to the bowel followed by an abdominoperineal prostatovesiculectomy and cystectomy.

Any one of these four types of radical prostatectomy may be indicated in a group of selected cases; but if the patients report for treatment in the early stages of the disease or have responded favorably to hormone therapy, either the first or second type of procedure will offer a reasonable possibility of cure. In these cases the prognosis is, therefore, much more favorable and the technic easier and less complicated. However, when it can be demonstrated by cystoscopic and urographic examination and bladder biopsy that the tumor has extended into the bladder, the more radical procedure of type III, as advocated by Young, will be in order.<sup>21</sup> Regarding the still more radical operation type IV, intended for treatment of very advanced stages of the disease, it is emphasized that this procedure can likewise be safely performed during earlier stages as an added effort to insure cure by a more radical operation just as we employ a combined abdominoperineal cystectomy, prostatectomy and seminal vesiculectomy in early or late stages of carcinoma of the bladder. However, as the malignant disease of the prostate advances and one is confronted by a patient with a so-called frozen or fixed pelvis due to adhesions and possibly multiple metastases, this fourth,

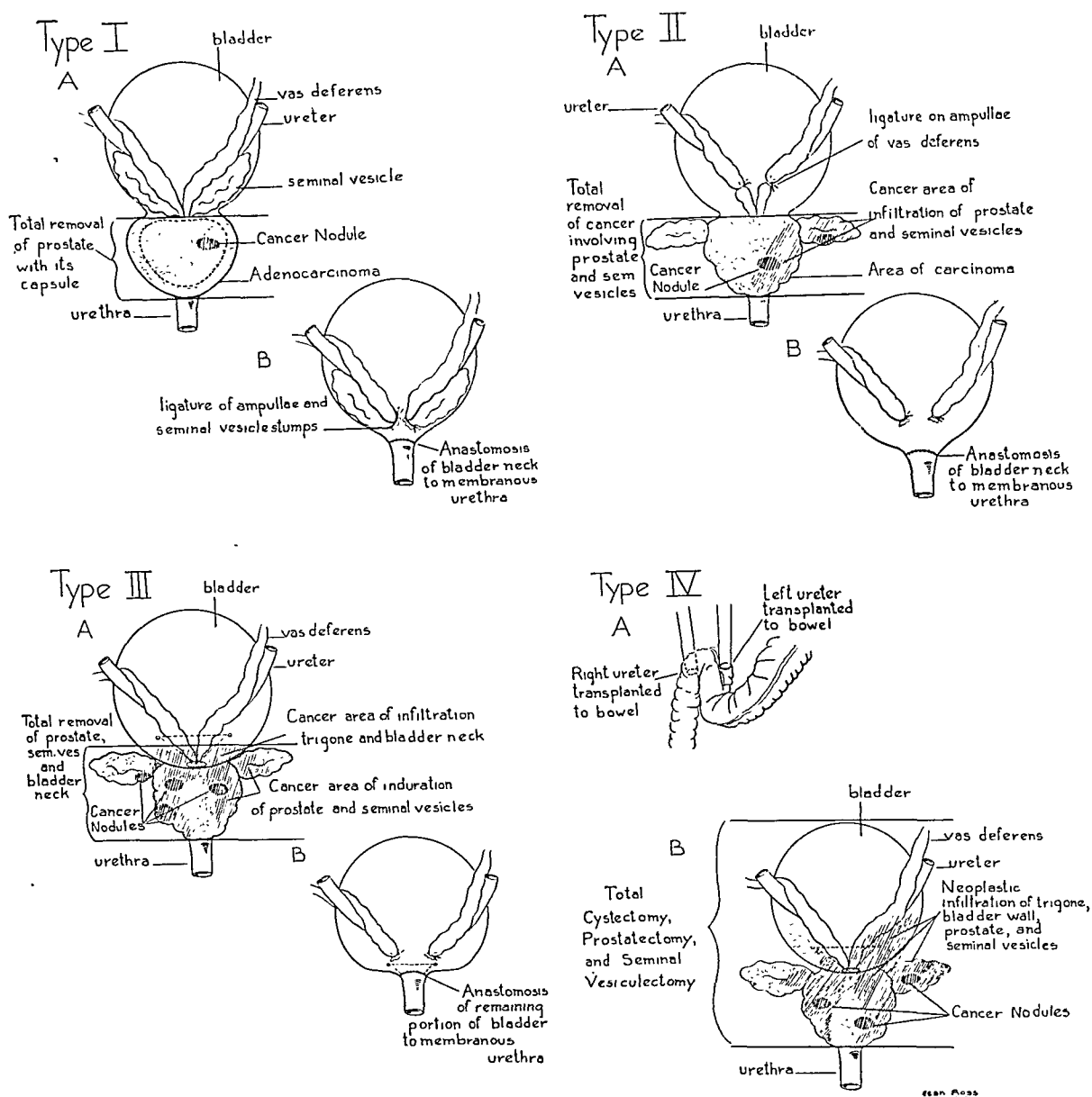


FIG. 3. Types of operation indicated for the radical cure of various stages of prostate cancer. *Type I:* For adenocarcinoma of the prostate, *without* involvement of the seminal vesicles, in which the primary lesion has not extended beyond the capsule. Here the procedure should be total removal of the prostate with its capsule as illustrated in Figure A followed by anastomosis of the bladder neck to the membranous portion of the urethra as shown in Figure B. *Type II:* For carcinoma of the prostate with involvement of the seminal vesicles in which the primary lesion has extended beyond the capsule. Here the procedure should be perineal prostateseminal vesiculectomy as illustrated in Figure A followed by anastomosis of the bladder neck to the membranous urethra as shown in Figure B. *Type III:* For carcinoma of the prostate with involvement of the seminal vesicles and bladder neck in which the more radical procedure of total removal of the prostate, seminal vesicles and bladder neck is indicated as shown in Figure A followed by anastomosis of the membranous urethra to the remaining portion of the bladder as shown in Figure B. *Type IV:* For a still more advanced stage of carcinoma of the prostate involving the seminal vesicles, the lateral walls of the bladder, the trigone and one ureteral orifice. Here, following preliminary diversion of the urine by transplantation of the ureters to the bowel (Fig. A), the procedure should be a combined abdominoperineal total cystectomy, prostatectomy and seminal vesiculectomy in an effort to obtain a permanent cure by radical surgery as illustrated in Figure B. Any of these four types of radical operation for carcinoma of the prostate can be applied in well selected cases, following preliminary hormone therapy, with gratifying results.

most radical type of operation has limitations and contraindications. In fact in two cases in which we had planned to do a combined abdominoperineal prostatectomy for carcinoma of the prostate with involvement of the bladder the patients were left in such a weakened condition by other palliative surgical interventions that the more radical procedure could not be attempted. One of these patients died shortly thereafter of general carcinosis. In the other patient a suprapubic cystostomy for palliation was performed in the final stages of the disease. In some of these cases in which the fourth type of operation might seem indicated but in which the disease has apparently advanced too far to justify the procedure, the administration of hormones may so change the tissues as to facilitate operation and render this most radical intervention possible. With the patient a good operative risk, with metastases showing regression and responding to hormone therapy and in the absence of cardiorenal or other contraindications, the fourth type of operation would seem justifiable as an attempt to remove surgically as much of the expanding malignant growth as possible.

Finally, there is another large group of patients in whom other methods of treatment have failed such as transurethral resection, castration, retention catheter, cystostomy, radium and x-ray therapy and other medical and surgical procedures. In such cases cure by radical operation may *still* be possible since the technical difficulties of radical perineal prostatectomy are diminished by preliminary hormone treatment which may produce demonstrable changes in the affected tissues. Even if castration or the administration of diethylstilbestrol, or both, finally fail to yield results after transitory improvement, I have found that a similar renewed regression with shrinking and softening of the gland may be achieved by administration of progesterone, the corpus luteum hormone of the ovary.

It is my earnest hope that in the future a full knowledge of the technic of radical

perineal prostatectomy will be made an obligatory requirement for all graduating urologists. There can be no question that the difficulty of this operation as well as the dearth of experience in its use, constitute barriers to its more widespread application. Only very few urologists have mastered this technic and have adequate experience in its performance. The operation is, of course, more difficult than a transurethral resection but at least it offers the patient a fifty-fifty chance of cure and is not, like transurethral resection, a veritable invitation to recurrence and dissemination of the malignant disease. In many cases perineal prostatectomy may prove futile but at any rate the patient loses nothing by undergoing the operation since he obtains the same palliative relief which he might have gained by transurethral resection and at the same time gains a fifty-fifty chance of being cured, which is not offered by the transurethral operation.

It is of the greatest importance that patients be duly impressed with the fact that the good effects resulting from preliminary hormone therapy will almost certainly be transitory and that delay in radical operation at the time of maximum improvement may result in recurrence of both clinical and anatomic symptoms, rendering an eventual operation much more difficult and possibly futile (Cases III, IV, VII, VIII, XIII and XIV).

#### CASE REPORTS

CASE I. R. E. W., aged sixty-five years, was referred to us for radical perineal prostatectomy for early carcinoma of the prostate gland, January 20, 1945. He had been ill since 1939 with the usual symptoms of nocturnal and diurnal frequency, dysuria, lumbago and pain across the lower part of his back. An aspiration needle biopsy done January 29, 1945, confirmed the diagnosis of adenocarcinoma of the prostate. He was placed on stilbestrol, 0.5 mg. three times a day, urinary antiseptics, vitamin B complex and a short course of prostatic massage with medical instillations, bladder irrigations and sounds once or twice a week. Under this treatment the gland

became softer and diminished in size; by the end of the second month of hormone therapy all symptoms had disappeared and the results of cystoscopic, urethroscopic, roentgenologic and urographic examinations were all negative. For this reason radical operation was indefinitely postponed. However, roentgen examination of the chest revealed pulmonary metastases. He was then placed on intensive antianemic therapy to combat an increasing secondary anemia and referred for ambulatory treatment. He improved steadily and reported that he felt much better. Rectal palpation on March 18, 1946, revealed a soft, shrunken gland with no evidence of carcinoma. This patient died of a heart attack on September 16, 1946. Autopsy revealed a ruptured aortic aneurysm. Several sections of the prostate gland showed no evidence of malignancy. There were no signs of metastases in the lungs. In this case, therefore, the astonishing post-mortem findings indicated a complete disappearance of the malignant disease which had been demonstrated at biopsy. This unusual retrogression and control of the disease was attributed to the effects of hormone therapy.

CASE II. A. R., aged fifty-eight years, was referred to us on January 5, 1948, with a diagnosis of adenocarcinoma of the prostate. His symptoms included hematuria, difficulty in urination, marked diurnal and nocturnal frequency. In July, 1947, he had been castrated and a transurethral resection had been done. After having been on hormone therapy for six months he complained of marked gynecomastia and severe pain in the gluteal region and lower back radiating to the legs. He had been under continuous medical care here and abroad and was taking morphine for relief of pain three or four times daily. Rectal palpation on January 5, 1948, revealed adenocarcinoma of the prostate of enormous size. He had 2 ounces of residual urine and a stricture of the urethra; his urine was cloudy with pus. He was advised to have a radical perineal prostatectomy. Because of persistence of symptoms in spite of stilbestrol therapy, he was given progesterone. After three or four weeks of this treatment he began to show marked improvement. Pain had disappeared, the gland had diminished in size and the amount of residual urine was reduced to  $\frac{1}{2}$  ounce. Also his other symptoms, namely, frequency of urination and gynecomastia had disappeared; the pros-

tate gland had become soft and small. A radical perineal prostatectomy should have been done at this time but unfortunately, the patient was feeling so well that he left town.

In two other cases a similar retrogression was observed following administration of the corpus luteum hormone after other hormone therapy had failed. The patient in Case II was so relieved from his painful symptoms that he no longer needed to take his daily doses of morphine.

CASE III. P. A. G., aged sixty years, was referred to us on July 20, 1944, complaining of urinary symptoms, namely, frequency day and night, urgency, dysuria, dribbling, pain in the perineal region and constipation. The residual urine was 2 ounces. Following the usual urologic work-up a diagnosis was established of adenocarcinoma of the prostate. He was at once placed on stilbestrol, 0.50 mg. three times a day, urinary antiseptics and vitamin B complex and given a short course of prostatic massage, medical instillations and dilatations of the urethra. Under this treatment the prostate gradually diminished in size and on August 8, 1944, he was subjected to a radical perineal prostatectomy. The histologic report confirmed the clinical diagnosis of adenocarcinoma of the prostate. The seminal vesicles were not involved; therefore, type I operation sufficed. There was no evidence of recurrence or metastases present. A Foley catheter was introduced for drainage and removed fourteen days after the operation. The patient had good control while recumbent but on rising showed slight dribbling and terminal incontinence. Following dilatation of the urethra with a Kollman dilator these symptoms subsided. By November 1, 1944, when he left town, he had good control, his bladder capacity was normal and he had no urinary symptoms or pain and no residual urine. In this case it appears, therefore, that the radical perineal prostatectomy following hormone preparation of the patient has resulted in a cure (four years).

CASE IV. R. R., aged sixty-four years, five years prior to admission had undergone a transurethral resection and operation for double inguinal hernia. When referred to us on March 16, 1943, he had been suffering from a fever, pyuria, hematuria and pain in the right kidney with marked diurnal and nocturnal



frequency, being forced to empty his bladder every half hour during the day and three or four times during the night. He also suffered from difficulty in urination as well as urgency. Rectal palpation revealed a prostate enlarged to three and a half times its normal size, of a leathery consistency, with induration of the posterior lobe and stony hard nodules in the right lateral lobe. The condition was diagnosed as adenocarcinoma. He had 2 ounces of residual urine. A complete urologic survey was ordered. Biopsy findings were positive. The patient was placed on stilbestrol, 0.5 mg. three times a day, urinary antiseptics and cathartics. After about one month on this regimen he showed considerable improvement. The gland had diminished in size and was of a softer consistency. He was admitted to the hospital April 15, 1943, and subjected to a total perineal prostatectomy. The histologic findings in the operative specimen confirmed the diagnosis of adenocarcinoma. He left the hospital on May 12, 1943. Convalescence was uneventful but a perineal fistula was left and the wound did not heal completely until May 29, 1943. Following the operation he also suffered from slight incontinence for which he was treated by dilatation with sounds and Kollman dilators up to No. F-45. Continence was gradually restored and at present the patient has no urinary symptoms. When last seen in 1948, five years after the radical operation, he was in excellent condition. X-ray examination revealed no signs of metastases.

CASE V. H. G., fifty-nine years, was referred to us on November 20, 1945, complaining of dysuria and diurnal and nocturnal frequency. He had been subjected to a left vasectomy some twenty years prior to admission and was now complaining of right renal colic, hematuria and dribbling. Six months before he had passed a stone. He complained of slight pain in the perineum and chronic constipation. Rectal examination revealed a prostate enlarged to four times its normal size, adenomatous in type and of a leathery consistency. Both seminal vesicles were palpable but there was no infiltration or induration except a hard, stony nodule in the left lateral lobe of the prostate. A complete urologic survey was made and the roentgen findings ruled out prostatic calculi; the diagnosis was adenocarcinoma of the prostate. The patient was placed on 0.5 mg. stilbestrol three times a day, urinary anti-

septics, vitamin B complex and veracolate tablets. The residual urine was 1½ ounces. On April 2, 1946, a total perineal prostatectomy was performed and three weeks later the patient was discharged with a healed perineal wound. Postoperatively he was placed on a maintenance dose of stilbestrol. He was left with a slight diurnal incontinence for which he was treated with urethral dilatation and by the end of June he had regained control. When seen in December, 1946, he was in excellent general condition and showed no evidence of metastases. To all appearances he was cured. According to the most recent report he is still in excellent condition and working.

CASE VI. M. G., aged eighty-five years, was referred to us on November 3, 1943, with a diagnosis of carcinoma of the prostate gland. He had suffered from both nocturnal and diurnal frequency for about two years. Rectal palpation revealed the prostate gland enlarged to four and one-half times its normal size. The gland was fixed, adenomatous and of a leathery consistency, with several hard nodules in the posterior and two lateral lobes, obviously an adenocarcinoma. The seminal vesicles were enlarged and palpable due to chronic inflammation. He was submitted to a complete urologic survey and put on stilbestrol therapy. A radical total perineal prostatovesiculectomy was done on December 28, 1943. Histologic examination of the operative specimen confirmed the diagnosis of adenocarcinoma. The perineal wound healed nicely and the patient had good control of his bladder while in bed but slight incontinence while in an upright position persisted for two or three months and finally subsided following urethral dilatation. He was placed on a maintenance dose of stilbestrol and vitamin B complex. His condition improved markedly and in April, 1945, he was reported in excellent health, having gained in weight. This patient is still alive and well.

CASE VII. M. P., aged sixty-two years, was referred to us on February 16, 1947, with a diagnosis of adenocarcinoma of the prostate gland. He complained of dysuria, difficulty and frequency of urination day and night and pain in the perineum, rectum and bladder region. Rectal palpation revealed a gland enlarged to five times its normal size, of stony hardness and firmly fixed. Both seminal vesicles were palpable, distended and chron-

ically inflamed. There were 4 ounces of residual urine. The patient was placed on stilbestrol, 0.5 mg. three times a day. After about two months he showed marked improvement in symptoms and reduction in the size of the prostate. Nocturnal frequency had diminished from six times to one or two and the residual urine had dropped from 4 ounces to 2 ounces. A complete urologic survey was made but all findings, including x-ray and intravenous urography, were negative. Against advice he left town on April 4, 1947. This patient should have had a radical perineal prostatectomy at that time for cancer of the prostate but because of his good general condition and absence of symptoms refused to be operated upon.

On November 14, 1947, he returned with a recurrence of all symptoms, namely, backache, rheumatoid arthritic pain in the lumbosacral region radiating to the legs, sciatic pain, pain in the perineum, rectum and suprapubic region. He was emaciated, having lost about 30 pounds in weight. Examination of the urine revealed pyuria and hematuria. The residual urine had increased to 16 ounces. During his sojourn in the South he had received no medication whatsoever. He was again placed on urinary antiseptics and on stilbestrol, 2 mg. three times a day, with vitamin B complex and veracolate for constipation as well as nembutal,  $1\frac{1}{2}$  gr. three times a day, for sedation and pantopon for relief of pain. X-ray examination and excretory urograms at this time revealed a large, functionless hydronephrosis and hydro-ureter on the left side caused by the carcinoma and enlarged prostate which had produced atony and overdistention of the bladder.

The patient was gradually prepared for operation. His symptoms subsided but the serum acid phosphatase was higher than during his first examination. However, x-ray examination revealed no bony or organic metastases. Cystoscopy on December 1, 1947, showed that the tumor was still encapsulated and limited to the prostate gland. As a result of hormone treatment his residual urine was gradually reduced from 16 to 4 ounces. He was again relieved of pain and symptoms and this time consented to the radical operation. On December 11, 1947, he had a total perineal prostatovesiculectomy. He had an uneventful convalescence. The histologic examination of the operative specimen confirmed the diagnosis of adenocarcinoma of the prostate gland. He

is in good condition and the last check-up in April, 1948, showed no signs of recurrence or metastasis. Roentgen examinations including intravenous urograms disclosed no metastases and no residual urine; the left, functionless, hydronephrotic kidney had regained its function and had returned to a practically normal picture. The patient's general condition is excellent and he has gained 28 pounds since the time of his radical operation.

This case is of interest because it disclosed that even in cases of recurrence following neglected treatment and discontinuance of hormone therapy for a period as long as seven months, a renewed administration of stilbestrol may again cause a retrogression of the tumor. Owing to the presence of the functionless left hydronephrosis and residual urine in the bladder preoperative preparation of the patient included introduction of a retention catheter and continuous irrigation of the bladder for a period of two weeks. Also, the preoperative dose of hormone was increased to 2 mg. orally three times a day and one intramuscular injection of 5 mg. stilbestrol daily, totalling 11 mg. of hormone daily. When this patient returned after neglecting treatment for seven months, examination had revealed a "frozen" pelvis with a fixed prostate and extracapsular extension of the malignant process, which rendered him practically inoperable. However, within three weeks after resuming hormone therapy in the increased dosage the gland once more had diminished in size and softened to such an extent that operation became possible.

CASE VIII. J. C. P., aged seventy-four years, had undergone transurethral resection elsewhere three years previously. He was left with a urethral stricture, intermittent retention, hematuria, pyuria, marked frequency day and night, urgency, and difficulty in urination. Rectal palpation revealed the prostate gland enlarged to about four or five times its normal size and irregular in shape. It was of a leathery consistency with marked induration of the left lateral lobe involving also the left seminal vesicle. A diagnosis of adenocarcinoma of the prostate gland was established. The residual

urine was 3 ounces. A filiform stricture of the urethra was dilated with bougies and sounds up to No. 24-F. The patient was placed on stilbestrol, urinary antiseptics and vitamin B complex.

On August 27, 1943, an internal urethrotomy was done for traumatic impassable stricture of the anterior urethra. On September 25, 1943, a radical perineal prostatovesiculectomy was performed with resection of the vesical orifice followed by anastomosis of the remaining portion of the bladder to the membranous portion of the urethra. Convalescence was complicated by an infection of the perineal wound with resulting slough of tissue, which healed by granulation after five weeks' hospitalization. This complication resulted in urinary incontinence.

In this case it is quite clear that the transurethral resection did not check the development of the cancer in the prostate gland. The operative specimen was subjected to histologic study which confirmed the diagnosis of adenocarcinoma. The cancer had developed to such an extent that a radical operation of type III was indicated. With this radical procedure the patient apparently has been cured of his primary neoplastic disease of the prostate gland. According to recent reports he is in excellent health and has gained in weight.

CASE IX. J. B. W., aged fifty-eight years, was referred to us on September 17, 1938, with a diagnosis of carcinoma of the prostate. He complained of soreness and slight pain in the bladder neck and perineum, diurnal and nocturnal frequency, difficult urination, dribbling and impotence for the past one and a half years. This man had a family history of carcinoma. Four years earlier he had been treated for prostatitis with no relief. Rectal palpation revealed a firmly fixed, stony hard prostate of irregular shape. He was on stilbestrol and a complete urologic survey was ordered but yielded negative results. The residual urine was  $1\frac{1}{2}$  ounces. Cystoscopy revealed a minor obstruction due to hypertrophy of the median and two lateral lobes of the prostate for which a transurethral resection was done on September 23, 1938. Histologic study of specimens obtained at transurethral resection yielded negative results. Also the serum phosphatase

and blood chemistry appeared normal. He was discharged from the hospital October 12, 1938, with no residual urine and feeling comfortable. About 25 Gm. of tissue had been removed. The clinical diagnosis was carcinoma of the prostate but histologic proof was wanting at this time.

On November 20, 1939, he returned complaining of soreness in the bladder neck and nocturnal frequency. X-ray examination for metastases yielded negative results. Although the prostate under preliminary hormone therapy had shrunk to one-half its former size at the time of the transurethral resection, it was of a stony hardness, nodular and fixed; there was a marked induration of the posterior and two lateral lobes. The malignant process had now extended to the seminal vesicles and there was  $\frac{1}{2}$  ounce of residual urine. There was no stricture or obstruction in the prostatic urethra. The urinary symptoms recurred and a second transurethral resection was done. Seven months later he left town. As his symptoms again recurred he was subjected to renewed transurethral resections on three occasions elsewhere and finally a castration was suggested in the effort to relieve him. He became emaciated but refused orchiectomy and finally succumbed to his disease three and a half years after the first transurethral resection.

In this case we have another example of the futility of transurethral resection as a cure for cancer of the prostate. Even the palliative effects were only transitory. The case is, furthermore, an illustration of *positive clinical* indications of carcinoma with initially *negative histologic* findings. Removal of the median and two lateral lobes at the first transurethral resection could yield no information as to the malignant process located in the subcapsular portion of the posterior lobe. This region also was missed in needle biopsy. The rectal findings indicating scirrhous carcinoma of the prostate gland were finally confirmed by the course of the disease and fatal outcome as well as by histologic examination of later operative specimens.

CASE X. C. L., aged fifty-seven years, was referred to us on June 23, 1943. He complained of frequency, having to urinate every half

hour during the day and six times during the night, as well as urgency, difficulty in micturition, hematuria and pyuria. He had undergone a transurethral resection of the prostate six months before admission but as this operation had not relieved his symptoms, he sought further advice. Examination revealed cloudy urine which contained pus. Rectal palpation revealed a prostate of stony consistency enlarged to four and a half times its normal size, firmly fixed and containing many nodules. The seminal vesicles were palpable but not indurated or involved in the neoplastic process. There were 3 ounces of residual urine. Diagnosis was adenocarcinoma of the prostate. He was placed on stilbestrol therapy and advised to have a radical perineal prostatectomy, which he refused.

On March 27, 1944, he returned stating that he had undergone a second transurethral resection elsewhere in February, 1944, with bilateral orchiectomy which left him with a scrotal urinary fistula. His symptoms had persisted and he had become a drug addict in his vain attempts to obtain relief from pain. He complained of pain in the lumbosacral and gluteal region radiating to the legs as well as pains in the bladder, perineum and rectum. The urinary symptoms had grown worse and he was forced to wear a rubber urinal for incontinence. He was voiding 15 per cent and draining through the scrotal urethral fistula, with residual urine of 14 ounces. A suprapubic cystostomy was done for drainage. The scrotal and perineal infiltration around the fistula was likewise incised to drain a perineoscrotal abscess.

Roentgen examination revealed bony metastases and at this advanced stage of the disease all hope for cure was gone. He died two months later of his neoplastic disease and metastases.

This case illustrates the futility of transurethral resection in the early stages of adenocarcinoma of the prostate which might respond to the radical perineal operation. If this patient had consented to the radical operation following preliminary hormone preparation at the time when it was first recommended to him in 1943, his life might have been saved. He was spared no suffering by the palliative measures of transurethral resection and orchiectomy.

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This case presents a good example of the failure of palliative measures in a patient who could have been cured by early radical surgery.

CASE XI. J. R., aged fifty-one years, was referred to us on May 18, 1943. His chief complaints were rheumatoid arthritis and lumbago which had persisted for four months. He had to empty his bladder every half hour during the day and three or four times during the night. This man also had a family history of carcinoma. He suffered from terminal hematuria. Rectal palpation revealed a gland enlarged to five and a half times its normal size with hard and indurated right and left lobes, an irregular shape and two hard palpable nodules on the right lateral lobe. The diagnosis was adenocarcinoma of the prostate gland. Physical examination revealed a large tumor the size of a grapefruit to the left of the median line in the abdomen suggesting a retroperitoneal metastatic tumor. He had a urethral stricture and 4 ounces of residual urine. The patient was placed on stilbestrol, urinary antiseptics and vitamin B complex. X-ray examination and urography on May 29, 1943, showed an outward displacement of both kidneys and ureters caused by this retroperitoneal tumor. There were no bony metastases. The patient apparently was suffering from a bilateral hydronephrosis and hydro-ureter and showed poor renal function. He had an enormous retroperitoneal tumor believed to be a metastasis from a primary prostatic cancer in an advanced state; cystourethrography demonstrated upward displacement of the bladder due to the enlarged prostate as well as multiple strictures of the urethra. The diagnosis was adenocarcinoma of the prostate.

After having been on the usual hormone regimen for about eight months he showed marked improvement, with gain in weight and restored appetite. The stricture was now passable to No. 27 and 28-F. Rectal palpation showed that the prostate gland had become softer and was markedly reduced in size. There were no adhesions or hard nodules and the induration had practically disappeared. The residual urine had been reduced to less than  $\frac{1}{2}$  ounce. The dose of stilbestrol was then increased to 1 mg. three times a day but because of the resulting improvement in his

condition the patient refused the urgently recommended radical operation. On January 25, 1944, cystoscopy revealed an intravesical and intra-urethral enlargement of the prostate of the trilobar type. Once again the patient was urged to undergo the radical operation but again he refused. He was kept on hormone and urologic treatment and finally left town on July 27, 1945, free from symptoms and feeling greatly improved. He promised at this time to return for the radical operation. However, by the beginning of 1946 we learned that he had been subjected to transurethral resection and orchiectomy elsewhere. At this time x-ray examination revealed multiple bony and organic metastases. Cystostomy was done to permit drainage and he died four months later of general carcinosis. Here again the failure of orchiectomy and transurethral resection as a cure for cancer of the prostate is demonstrated.

CASE XII. R. P., aged fifty-nine years, was referred to us on May 4, 1943. He complained of frequency, day and night, urgency, difficulty in micturition, lumbago and pain across the lower back radiating to the legs. His urinary disturbances had been present for two years. Rectal palpation revealed adenocarcinoma. The patient was prepared and after cystoscopy, x-rays, and intravenous urography, he was admitted to the hospital for total perineal prostatectomy. There were 2 ounces of residual urine. His blood chemistry, blood count and phenolsulfonphthalein were within normal limits. An indwelling catheter was introduced and on May 18, 1943, a total perineal prostatectomy was performed. He was discharged four weeks later with the perineal wound healing. The pathologic report was adenocarcinoma. Following repeated dilatation of the urethra up to No. 28 French he was discharged. When reexamined on July 2, 1943, the perineal wound was completely healed and he had good urinary control. When last heard from in January, 1948, he was alive and well.

CASE XIII. V. A., aged sixty-five years, was referred to us on April 20, 1947. He had a history of hematuria, dysuria, difficulty in micturition, anemia, loss of 20 pounds in weight and a generally weakened condition, as well as chronic constipation and cardiorenal ailment. Two years previous he had suffered several attacks of pyelitis and renal colic. He had to urinate every half hour during the day and from six to seven times during the night.

The prostate was enlarged and stony hard, with nodules and a markedly irregular contour. The seminal vesicles were palpable and on the right side there was an infiltration of the seminal vesicle. The residual urine measured 8 ounces. The urine was cloudy and contained pus. The diagnosis was adenocarcinoma. Roentgen examination and intravenous urography revealed bilateral pyelonephritis, multiple prostatic calculi and an enormous enlargement of the prostate causing obstruction at the vesical outlet. The cystogram showed evidence of residual urine. Cystoscopy revealed multiple cellules and trabeculations in the fundus of the bladder as well as two diverticula caused by the obstructing prostate. The patient was placed on preliminary hormone therapy, urinary antiseptics, vitamins and veracolate, with the proper urologic and medical care. The residual urine was gradually reduced from 8 to 4 ounces and the patient's symptoms subsided. His general condition was greatly improved. The patient was admitted to the hospital for a complete urologic study and a retention catheter for drainage and gradual decompression of the bladder was introduced. The phenolsulfonphthalein test and the blood chemistry improved and the operation for radical perineal prostatectomy was performed on June 10, 1947. He had an uneventful convalescence and was discharged on June 26, 1947, with his perineal wound healed and with fair urinary control. In this case, too, histologic examination of the operative specimen revealed adenocarcinoma. His symptoms were relieved, he gained weight and last reports found him in excellent condition.

CASE XIV. C. R., aged sixty-eight years, was referred to us on October 11, 1947. His history revealed that in 1913 he had suffered from renal colic and hematuria. He had been subjected to prostatic treatments for difficulty in urination and terminal hematuria. There was marked frequency, day and night, and urgency. Rectal palpation revealed an adenocarcinoma of the prostate. There were  $2\frac{1}{2}$  ounces of residual urine. The patient was placed on hormone therapy, urinary antiseptics and vitamins and prepared for a total perineal prostatectomy following a routine complete urologic study, including x-ray, intravenous urography and cystoscopy as well as tests for blood chemistry, serum acid phosphatase and phenolsulfonphthalein.

On October 17, 1947, he was admitted to the hospital and an in-lying urethral catheter for drainage and gradual decompression of the bladder was introduced. The operation for total perineal prostatectomy was performed on October 21, 1947. He left the hospital on November 18, 1947, with his perineal wound almost healed. He still suffered from slight dribbling and incontinence in the upright position. When in bed his control was perfect. In this case the follow-up care consisted of urethral dilatation up to No. 30 French and No. 45 Kollman. By the beginning of January, 1948, his control had improved. He left town with his wound healed. The histologic diagnosis of the operative specimen was adenocarcinoma. His general condition was excellent, he had gained in weight, was more alert, with a better color and altogether very happy about the results of his radical operation.

CASE XV. J. R., aged fifty-nine years, was referred to us March 31, 1945, with a diagnosis of carcinoma of the prostate and diverticulum of the urinary bladder. He complained of difficulty in micturition, marked frequency day and night, urgency, dysuria and dribbling. Rectal palpation revealed a shrunken, indurated, stony prostate gland, with an irregular contour and a definitely scirrhus type of carcinoma. He had 2 ounces of residual urine. The patient was placed on hormone therapy and given a complete urologic survey which disclosed a diverticulum of the urinary bladder and obstructing carcinoma of the prostate. There were no signs of bony metastases and the patient was admitted for operation. A transurethral resection was carried out on May 7, 1945. He had shown no response to hormone therapy and was discharged on May 14, 1945, with cloudy urine but no residual urine. Treatment was continued with urethral dilatation and bladder irrigations. Subsequent cystoscopic examination revealed no obstruction at the vesical outlet; and since the bladder diverticulum empties perfectly there is no residual urine, and no infection in the bladder at the present time. In this case the scirrhus nature of the carcinoma was obvious and histologically proved from a study of the operative specimen. Cystoscopy on November 21, 1946, revealed the same findings. Although he had no urinary symptoms, he complained of pain across the lower back, radiating to the legs, most probably caused by the admittedly in-

operable scirrhus carcinoma of the prostate. The patient has been on hormone and proper medical treatment which has apparently controlled his disease to a certain extent. This improvement can hardly be expected to last much longer.

#### OPERATIVE TECHNIC FOR RADICAL PERINEAL PROSTATECTOMY

The operation for radical perineal prostatectomy is carried out under spinal anesthesia using 150 mg. of nupercaine which gives, as a rule, perfect anesthesia. Of the four types of radical prostatectomies for cancer of the prostate herein described, types I and II are the most commonly employed, and therefore the technic employed in type II will be described here in detail. Since the technic of type II is merely an extension of that employed in type I, the only difference being the added removal of the seminal vesicles and ampullae, a description of the technic used in type II will suffice. The steps in the procedure used by the author, are as follows:

With the patient in the exaggerated lithotomy position, sound No. 28 is passed and replaced by the urethral prostatic retractor. The scrotum is elevated and retracted. A curved incision is made in the middle portion of the perineum, running from one ischial tuberosity to the other, through the skin fascia, and is continued by blunt dissection deep into the two ischial fossas. The central tendon is divided and retracted. The bulb is also retracted with the bulb retractor. The recto-urethralis muscle is then divided and the two levator ani muscles are separated and retracted. The rectum is retracted and separated from its attachments at the apex of the prostate. With good exposure of the glistening fascia of Denonvilliers, a transverse incision is made in the posterior surface of the prostate to permit free dissection of the prostatoperitoneal aponeurosis and exposure by blunt dissection of the right and left seminal vesicles as well as both ampullae. The vasa are clamped, cut and tied just above their ampullae.<sup>22</sup> The long urethral

tractor is then removed and replaced by a prostatic tractor, which is inserted through a small opening in the prostatic urethra at the apex of the prostate, for traction and better exposure. The prostate and its capsule are dissected free anteriorly and laterally, after sectioning the membranous urethra at the apex of the gland and the retropubic prostatic ligament, in order to liberate the whole prostate anteriorly, so that it can be removed *in toto*, with its capsule and both seminal vesicles and ampullae. Two Allis clamps are placed on each side of the bladder neck. A No. 22 Foley urethral catheter is introduced through the urethra for drainage. After a good exposure and complete control of the bleeding areas four sutures are inserted in the four corners of the neck of the bladder to insure complete hemostasis. The bladder neck is then anastomosed to the membranous portion of the urethra by placing several interrupted sutures of chromic catgut No. 1 anteriorly, laterally and posteriorly. Then the remaining portion of the posterior layer of the Denonvilliers' aponeurosis is closed and sutured to the anterior portion of the same fascia, in order to reconstruct and reinforce the anastomosis of the bladder neck to the membranous urethra, and in an effort by this plication of the Denonvilliers' fascia to insure complete anastomosis and perfect urinary control. The wound is closed in layers without drainage. The two levator ani muscles are approximated with interrupted chromic catgut sutures and the floor of the pelvis is closed with interrupted chromic catgut sutures. The skin is closed with interrupted silk sutures. The bag of the retention catheter is distended with 30 cc. of fluid and the catheter is irrigated until the returned fluid from the bladder is clear.

*Postoperative Care.* The immediate results of perineal prostatectomy are usually satisfactory, and after the first, second and third types of operations listed, the perineal wound is closed without packing. A Foley urethral catheter is introduced and placed in the urethra for drainage and continuous

irrigation of the bladder. The stitches are removed on the sixth postoperative day and the catheter by the twelfth day. Blood transfusions to meet the individual requirements must, of course, be given as usual both before and after operation. Also, in order to prevent infection and to secure primary healing of the wound, routine chemotherapy is administered for ten days to one week, before and after operation. A well balanced diet with plenty of vitamins and fluids is also needed. In addition, the patient should receive a maintenance dose of estrogen. As little as 1 mg. daily of the synthetic hormone, stilbestrol, will often suffice, is well tolerated and will to a certain extent prevent the recurrence of metastases elsewhere in the body. The organic estrogen preparation, estinyl, .05 three times a day, yields even more favorable results and is of special value for relief of pain. Dolophine has also proved useful in this respect. Of course these patients must be kept under observation and be requested to return at intervals for examination and proper follow-up medical and urologic care.

*Complications.* The morbidity and mortality of radical perineal prostatectomy should in the hands of the experienced surgeon be no greater than that of any other type of prostatectomy, including transurethral prostatectomy. With the recent progress in the control of infection with the sulfonamides and antibiotics such as streptomycin and penicillin, the wounds of the so-called formidable radical perineal operation heal by primary union. With adequate anatomic exposure of the various perineal landmarks, there should be no uncontrollable hemorrhage or rectal fistulas. The other greatly feared complication of perineal prostatectomy, namely, urinary incontinence, occurs very rarely following meticulous anastomosis of the membranous portion of the urethra to the bladder neck and reinforcement of the anastomosis by proper plication of Denonvilliers' fascia. However, urinary incontinence is a complication which may develop following any

type of prostatic surgery even the relatively simple transurethral resection. But with proper follow-up care, as time goes on both immediate and late results of the operation will be improved.

NEW HORIZONS IN THE TREATMENT  
OF DEFINITELY INOPERABLE  
ADENOCARCINOMA AND SCIRRHOUS  
CARCINOMA OF THE PROSTATE

Recently attention has been drawn to the fact that recurrence of metastases and painful symptoms following orchiectomy, hormone therapy or both can be held in check by the administration of massive doses of the female sex hormone (diethylstilbestrol), up to 305 mg. daily, including 100 mg. three times a day after meals by mouth and 5 mg. daily by intramuscular injection. The absence of symptoms of intoxication following such heavy doses is attributed by Huggins<sup>23</sup> to the fact that most of the hormone administered is excreted through natural channels. Dr. Shepard, of Great Britain, and Dr. Elmer Belt of this country, have had similar experiences.<sup>24</sup> With such heavy doses, retrogression of the bony metastases is said to take place more rapidly than with smaller doses, and the unpleasant side effects of the smaller doses are also less marked following massive dosage. These findings would suggest that the administration of massive doses of the female sex hormone in hopeless and inoperable cases offers us one more important *palliative* method of slightly prolonging survival and relieving pain. This would pertain particularly to the 20 per cent group of very advanced cases with multiple metastases, "frozen pelvis" and *per se* inoperable, in other words, those cases which fail to meet our criterion of operability.

The author has used still another method of obtaining this phenomenon of temporary arrest of symptoms and inhibition of metastatic activity, namely, the administration of progestin or progesterone in daily doses of 25 mg. by intramuscular injection and 25 mg. orally in tablet form (progestoral).

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These crises of anatomic regression in the acute stage of the disease seem to coincide with the symptomatic relief obtained by hormone therapy.

Finally, in those in whom the hope of cure has been abandoned and in whom palliative hormone therapy, castration and repeated transurethral resection fail to alleviate the symptoms, and in which none of the types of operation described, not even the fourth type, seem justifiable, one may still resort to suprapubic cystostomy. With this intervention, drainage is insured, the bladder is placed at rest, and for the short remaining period of his life the patient is relieved of agonizing pain and urinary symptoms, as illustrated in Cases x and xi of this series.

PLACE OF TRANSURETHRAL RESECTION  
IN THE TREATMENT OF CARCINOMA  
OF THE PROSTATE GLAND

Another *palliative* method which does not, however, prepare the patient for curative surgery and which has become almost a routine procedure during the last decade is *transurethral resection*. This intervention is directed toward relief of urinary obstruction and by accomplishing this purpose may prolong the life of the patient and render him more comfortable for a few months or years. Sooner or later the symptoms recur, the malignant tumor still *in situ* resumes its growth and its metastatic activity and the patient succumbs. The operation for transurethral resection has its legitimate indications in selected cases and in hopeless cases of scirrhous carcinoma which will not respond to hormone treatment. For advanced cases of malignancy with obstruction at the bladder neck transurethral resection is still a more convenient operation than a permanent cystostomy (Case xv).

The use of transurethral resection in adenocarcinoma of the prostate is but an acknowledgment of defeat. Transurethral resection has no statistics of cure comparable to the 50 per cent salvage obtained by total or radical perineal prostatectomy.



The posterior lobe of the prostate which is the most common site of the primary tumor is not removed in transurethral resection. The failure of this operation as a cure for carcinoma of the prostate is obvious and cannot be denied. The author has seen a case in which transurethral resection had been repeated as many as six times within three years. This patient still bears his primary tumor *in situ*, and the latter has by this time extended into the bladder, giving rise to obstructive symptoms requiring additional surgery for temporary relief of pain (Cases II, IX, X and XI).

Another great advantage in employing radical perineal prostatectomy is that no further surgery is required following this operation; whereas transurethral resection since it involves only partial removal of the gland, may have to be repeated and the late results of this less radical procedure are not as satisfactory as those resulting from the radical removal of the gland and its capsule via the perineal route.

It seems inevitable that with the new aid offered by preliminary hormone preparation of the patient, the demand for *radical perineal prostatectomy* in the treatment of carcinoma of the prostate gland will markedly increase. For with operability increasing to include some 80 per cent of cases with this new method of preoperative preparation of the patient, the radical operation will offer a prospect of cure in one-half of these or 40 per cent of cases, as compared with the operative cure of 5 per cent possible before the advent of this new approach which renders *inoperable* cases *operable*.

#### CLINICAL CONSIDERATIONS AND RESULTS OF THE RADICAL OPERATION

At the present time any clinical discussion of carcinoma of the prostate must take into consideration two eras, namely, that preceding the advent of hormone therapy and that following this new approach. It is a well known fact that in the former period late results of radical perineal prostatectomy in the operable group

yielded about 50 per cent of cures.<sup>25-31</sup> Since the introduction of hormone therapy or orchiectomy for temporary control of the disease it is obvious that more cases are becoming amenable to radical surgery, and accordingly the percentage of cures possible by radical surgery will be definitely increased.

No actual cures and only very few five-year survivals have been reported as a result of transurethral resection, orchiectomy or hormone therapy *per se* or from the use of all three of these methods in combination. Relief of symptoms and prolongation of life have been achieved but there has been no report of final cure with these palliative methods of treatment. The cancer is still *in situ*. At present the results obtained in patients subjected to the radical operation appear to be not only more numerous but more gratifying. Before the hormone era only some 10 per cent of cases were operable. Now the figures have been reversed as a result of routine preliminary hormone therapy as a preparation for radical surgery, the earlier 80 to 90 per cent of inoperable cases having been reduced to only about 20 per cent.

From a study of the small series of cases here reported no definite conclusions are permissible, since besides the insufficient number of cases not enough time has elapsed for a proper evaluation of results. But the clinical results have been most striking; and even though a definite cure cannot be demonstrated at the present time, at least none of the patients subjected to the radical operation has died to date, and they have not only gained in weight but are also completely relieved of their urinary symptoms and for the present, at least, must be regarded as cured of their cancer.

Without postmortem examination or biopsy studies no one could definitely rule out the presence of cancer. However, rectal palpation in these patients subjected to radical perineal prostatectomy reveals no palpable tumor mass, there is no residual urine, repeated x-ray examinations for

metastases have proved negative, as likewise all intravenous urographic studies and all routine laboratory tests. On the other hand, it is generally known that patients subjected during the past ten years to transurethral resection or any other palliative treatment have died within two, three or four years after diagnosis has been established. In four cases of the present series the follow-up period has been too short for final conclusions but these patients are all well. Of six cases followed up for three years, all are alive and well. Four patients who were followed up for more than five years are alive and well and free from symptoms. There has been no mortality. In one patient subjected to the radical operation type III more than five years ago incontinence developed and persisted for more than three years.

The technic of the radical operation for perineal prostatectomy has been greatly simplified, not only as a result of the proper preliminary preparation of the patient by administration of hormone but with the aid of modern chemotherapy, and there has been a consequent reduction of post-operative complications, morbidity and mortality. The control of the disease rendered possible by hormone therapy has also contributed to more gratifying final results.

As the situation now stands, as soon as diagnosis of adenocarcinoma of the prostate is established, the patient should be prepared by administration of hormone and chemotherapy for the radical operation which, if at all possible, is the procedure indicated.

In other words, it seems unnecessary to do multiple transurethral resections or castration which signify only procrastination and postponement of the final fatal outcome of the disease for which today the only known cure is radical operation.

#### SUMMARY AND CONCLUSIONS

1. New horizons appearing in the surgical management of carcinoma of the prostate gland demand a revision of the indications for *radical perineal prostatec-*

*tomy* on the basis of hormone control of the disease as a preliminary preparation of the patient for radical surgery.

2. A new clinico-anatomopathologic classification of cancer of the prostate as affecting operability is presented.

3. Four types of radical operation for the relief of various stages of prostatic carcinoma are presented and illustrated. The most commonly used of these procedures, type II, is described in detail. The technic of this radical perineal operation includes the total prostatovesiculectomy with the proper anastomosis of the membranous urethra to the bladder neck, followed by plication of Denonvilliers' fascia in order to reinforce and tightly close the prostatoperitoneal aponeurosis and thus prevent urinary leakage.

4. The new surgical aspect of the prostatic cancer problem presented opens a new avenue for more radical perineal surgery and a possible means of increasing the percentage of permanent cures.

*Inoperable* cases can be rendered *operable* by the transitory metamorphosis of the cancer and its metastases produced by the use of hormone (diethylstilbestrol) therapy. Before the advent of hormone therapy only 10 per cent of cases were amenable to radical surgery and 90 per cent of cases were totally inoperable.

Now, with these new aids in preparatory treatment of the patient, more than 80 per cent of cases of carcinoma of the prostate will become amenable to radical surgery fulfilling our criterion of operability and only 20 per cent remain inoperable. The latter are chiefly the scirrhus type of carcinoma.

5. The routine application of preliminary hormone therapy by increasing the number of cases amenable to radical operation should increase the salvage of victims of cancer of the prostate by radical operation from a calculated 5 per cent in the past (50 per cent of the 10 per cent operable group) to a possible 56 to 64 per cent of all cases (70 to 80 per cent of the now 80 per cent operable group). Moreover, in

the 80 per cent group now rendered operable it is more than likely that a still higher percentage of curability may be attained, judging by the clinical results of the small series of ten cases herein reported.

6. In cases in which the hormone effect of diethylstilbestrol or castration has been *exhausted*, similar temporary regressions can be obtained by administration of the *corpus luteum hormone*.

Preparation of the patient with small doses of diethylstilbestrol for radical operation, which permits complete removal of the primary focus, seems more logical than any method which leaves the primary malignant process *in situ*.

7. The small series of cases here reported illustrate the feasibility of the radical operation since there has been no mortality and the patients are free from urinary symptoms, as well as from any evidence of progression of their primary malignant disease.

8. The final evaluation of the new treatment here presented can be made only after a follow-up study of many years. For the present this new procedure seems to offer some chance of cure to many patients whose cases have hitherto been considered hopeless. In all events, such patients will lose nothing by submitting to the more radical operation, since it offers the same symptomatic relief as the palliative methods described. Should the author's conviction prove well founded, these patients will, moreover, also have been relieved of their primary malignant lesion. They will then have more than a fifty-fifty chance of complete cure since the organism, no longer forced to battle against the cancerous insult, can exert its intrinsic curative powers. The latter can be further supported by maintenance doses of the hormone and by indicated medical and urologic care.

9. In the future the presence of metastases, now acknowledged as responding to hormone therapy, may no longer deprive the patient of his only hope of cure by radical surgery.

10. With this new method of control of this practically incurable disease, the prog-

nosis for five-year cures of carcinoma of the prostate by radical surgery is greatly improved.

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# USE OF FIBRIN FILM IN REPAIR OF EXPERIMENTALLY PRODUCED HERNIAS\*

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THE problem of replacement of peritoneum and fascia in the repair of defects of the abdominal wall, such as large ventral hernias, has brought forth the use of autogenous grafts of fascia, muscle, bone and dermis and heterogenous grafts of alcohol preserved ox fascia. Foreign materials that have been used include silver wire filigree, steel and Vitallium plates. The irregular success of these materials, the frequent revisions and continued search for a more adaptable foreign substance led us to investigate fibrin film for this purpose.

Certain standards should be approached as closely as possible if success is to be attained by the use of a foreign material: (1) It must be innocuous and cause a minimal amount of tissue reaction. (2) It must be strong enough to withstand the intra-abdominal pressure and pull of the abdominal musculature. (3) It must in time either be replaced by a strong sheet of fibrous tissue or become firmly adherent to the tissues to which it has been sutured. (4) It must be available so it can be easily obtained when needed.

Fibrin film, developed by Cohn,<sup>1</sup> is a fractionation product of human blood plasma. In manufacture of the film the fibrinogen content (fraction 1) has been converted into fibrin by the action of thrombin (purified from fraction 111-2).<sup>2</sup> The film is composed of protein and a plasticizer. (The latter is a substance of low molecular weight, usually a liquid, incorporated to make the final product soft and flexible.) The character of the film may be modified by varying the conditions under which clotting takes place and by changing the amount and character of the

plasticizer present.<sup>3-5</sup> In this way anatomic structures can be imitated by the fibrin film.<sup>6</sup> The fibrin film used by us was similar to the film used by Bailey and Ingraham<sup>7-9</sup> as a dural substitute. It comes in a sterile ampule, is translucent and somewhat brittle, but after immersion in saline the physical properties are changed and it becomes soft and elastic, very much like a wet membrane.

Our first problem was to produce large herniations or wound disruptions and then attempt to prevent and repair them by using fibrin film. At this point it probably is well to clarify our conception of the difference between postoperative hernias and wound disruptions. Without entering into the highly controversial subject as to the cause of postoperative hernias or wound disruptions,<sup>10-12</sup> we have designated as hernias those conditions in which there is a protrusion of the viscera through the abdominal wall. Wound disruptions we have reserved only for massive herniations. We are in agreement with Kross<sup>13</sup> that these two conditions are differences of degree of the same pathologic phenomenon.

Rabbits of both sexes, varying from 1,800 to 3,200 Gm. in weight, were used. The operations were all done under sterile conditions and drop ether was used for anesthesia. In about one-half of the rabbits we used  $\frac{1}{750}$  gr. of atropine to reduce secretions from the respiratory tract. Eight rabbits were used for our first problem. (Table 1.) Through a right paramedian approach a 6 cm. incision was extended through the abdominal wall into the peritoneal cavity. The lower portion of the incision was then closed with a continuous

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suture of 00 silk through peritoneum, fascia and the abdominal musculature, leaving a 2 cm. gap in the upper angle of the incision. The skin and loose subcutaneous tissue were then approximated with a continuous 00 silk suture, thus leaving the

hernias about 1 cm. in diameter, not containing visceral contents and continuous but not communicating with a cyst-like structure which lay between the skin and the abdominal musculature. These cysts were filled with a thick, cheesy material in

TABLE I  
ABDOMINAL INCISION SUTURED EXCEPT FOR A 2 CM. GAP  
AT THE UPPER END OF THE WOUND

Animal No.	Sacrificed	Findings
1	20 days	Hernia 1 cm. long, containing tongue of the liver continuous with a thick-walled cyst filled with a creamy material; a cyst lay between the skin and abdominal muscles
2	10 days	No hernia or adhesions
3	14 days	No hernia or adhesions
4	10 days	No hernia; adhesions between peritoneum and underlying intestine
5	10 days	Hernia 1 cm. long, communicating with cyst-like structure containing mucoid material
6	10 days	Hernia $1\frac{1}{2}$ cm. long, containing no viscera
7	10 days	Hernia 2 by 1 cm., continuous with a thick-walled cavity, smooth lined and no contents
8	10 days	Hernia 1 by 1 cm., communicating with a smooth-walled space lying between the skin and abdominal musculature

upper 2 cm. of the incision covered only by skin and subcutaneous tissue. The rabbits were sacrificed at periods varying from ten to twenty days. In two rabbits, inspected on the tenth and fourteenth days, respectively, there was no evidence of any hernia. The gap left in the upper margin of the incision had healed over completely. In one rabbit there were adhesions between the peritoneum and the underlying viscera which were more dense at the upper, open margin of the wound. In one rabbit there was a small hernia, measuring  $1\frac{1}{2}$  cm. in diameter, into which a knuckle of intestine had protruded. In two rabbits there were small herniations, 1 cm. each, continuous with a smoothly lined cavity which lay between the skin and the muscle wall. In the remaining two rabbits there were small

TABLE II  
ONLY SKIN AND SUBCUTANEOUS TISSUE SUTURED—6 CM.  
GAP LEFT IN THE UNDERLYING ABDOMINAL WALL

Animal No.	Sacrificed	FINDINGS
1	3 days	Massive evisceration of the intestines through the abdominal wall and lying under the skin
2	7 days	Massive evisceration
3	5 days	Massive evisceration
4	8 days	Massive evisceration

one instance and a mucoid material in the other. Sections were taken through the entire abdominal wall, including the cysts, and slides were made for microscopic examination. In none of our series were we able to produce eviscerations as described by Kross<sup>14</sup> in a similar experiment carried out on sixteen rabbits. Freeman<sup>15</sup> attempted to produce wound disruptions in dogs by placing a tongue of omentum between the muscles, and he describes the formation of cysts which were filled with a lymph-like fluid.

In the next experiment (Table II) in four rabbits a 6 cm. paramedian incision was carried through the entire thickness of the abdominal wall, with the peritoneum, fascia and musculature left unsutured. Only the skin and subcutaneous tissue were closed with 00 silk. The rabbits were sacrificed at periods varying from six to eight days, and in each instance there was a massive wound disruption, with the intestines lying under the subcutaneous tissues. Subsequent experiments proved that we had established an operative procedure which would result in wound disruptions in 100 per cent of the rabbits and it now remained to study the use of fibrin film in the prevention or repair of these disruptions.

Ten rabbits were utilized for study of the value of fibrin film. (Table III.) In four rabbits the same operation was carried out as just described. In two rabbits a sheet of fibrin film measuring 7 cm. by 3 cm. was spread under the defect in the peritoneum.

TABLE III  
CASES IN WHICH FIBRIN FILM WAS USED TO REPAIR DEFECTS

Animal No.	Sacrificed	Technic	Findings
1	28 days	Fibrin film layed under peritoneum to cover defect; skin closed with silk	Massive evisceration of intestines; no evidence of fibrin film
2	30 days	Same as above	Same as above
3	30 days	Film tacked beneath peritoneum with mattress sutures; skin closed with silk	Massive evisceration of intestines; no evidence of fibrin film
4	40 days	Same as above	Same as above
5 and 6		Evisceration previously produced; attempt made to repair defects using sheets of film 5 by 4 cm., but in both instances sutures ripped out before the operation could be completed	
7	60 days	Window $4\frac{1}{2}$ by $1\frac{1}{2}$ cm. cut in abdominal wall; film 4 layers thick and 4 by $1\frac{1}{2}$ cm. sutured into defect; skin closed with silk	No hernia; film encapsulated in a cystic mass which plugged up the defect and was adherent to underlying intestines
8	60 days	Same as above	Same as above
9	80 days	Same as above	Same as above
10	54 days	Same as above	No hernia; the film was replaced by a neomembrane of connective tissue

No sutures were used in the abdominal wall. The skin was closed with silk. In two other rabbits the same procedure was carried out, except that the fibrin film was tacked into position with silk sutures to avoid slipping. The animals were sacrificed at periods varying from thirty to forty days and in each instance there were wound disruptions just as had been found in the previous experiment. In each instance the fibrin film had been completely absorbed and could not be identified.

In two rabbits, previously operated upon and a disruption produced, an attempt was made to repair the abdominal wall defects by using fibrin film. The defect in the peritoneum and fascia was bridged with a double layer of film measuring 5 by 4 cm. and this was sutured in place with silk mattress sutures, but before the experiment could be terminated the sutures cut

through the fibrin film, making the repair ineffective and the animals had to be sacrificed.

In four rabbits the technic was modified slightly. A similar approach was used through the skin and subcutaneous tissues and then a window, measuring 4 by  $1\frac{1}{2}$  cm., was cut out of the abdominal wall. Fibrin film folded into four layers and measuring 4 by  $1\frac{1}{2}$  cm. was sutured into the defect. Since it had been demonstrated how easily sutures cut through the film, small buttons about 1 mm. in diameter were cut out of the abdominal wall previously removed and used to strengthen the suture line. Even with the use of these buttons the fibrin film was sutured in place with extreme difficulty. The skin and subcutaneous tissues were then closed with silk. The rabbits were sacrificed at periods varying from twenty to sixty days. In none of the rabbits were there any post-operative hernias or wound disruptions. In one rabbit the fibrin film had been replaced by a very thin neomembrane. In the other three animals the original defects were filled by large cysts, averaging 5 by 2 by 2 cm., protruding down into the abdominal cavity and adherent to underlying loops of bowel. When these cysts were opened, they were found to contain cheesy-like material in which balled-up sheets of fibrin film in good states of preservation were embedded.

#### COMMENT

In the first phase of our problem (Table I) we demonstrated that wound disruptions could not be produced in rabbits merely by leaving a 2 cm. slit in the peritoneum and abdominal wall. This is contrary to the work of Kross.<sup>13</sup> We were able to produce small hernias in five of these rabbits, and in a great majority of these cases the hernias were associated with formation of cystic structures. These cysts have been described by other observers performing similar operations on animals, and it had been postulated that these cysts represented encapsulations of exudate from strangulated omentum or bowel which had

been purposely introduced into the operative wounds.<sup>15</sup> In several of our rabbits there were no viscera lying within the hernias so apparently the aforementioned explanation is not entirely valid. It is more likely that the peritoneal fluid seeps between layers of the abdominal wall and becomes encapsulated. As to the relationship of this process to eviscerations in man, Freeman<sup>15</sup> suggests that there is a cystic encapsulation of exudate just as in the rabbits, and acting like a wedge it separates the wound edges, preventing healing and resulting in wound disruptions. Whether such cysts can be prevented by adequate drainage and whether these cysts have a counterpart in the formation of postoperative hernias in man is not within the scope of this paper, and further work is now being carried out along these lines.

In the second part of the problem we produced massive wound disruptions simply by making a 6 cm. incision through the entire thickness of the abdominal wall and then suturing only the skin and subcutaneous tissues, leaving the muscle, fascia and peritoneum unsutured. It is interesting to note that in those animals in which small hernias were produced the incidence of cyst formation was very high, but in those animals with massive wound disruptions there was no evidence of cyst formation. The explanation that suggests itself is that large defects in the abdominal wall are self-draining, whereas small defects become readily blocked thus allowing the exudate to accumulate and become encapsulated.

The third phase of the experiment concerns application of fibrin film to repair defects in the abdominal wall. Whereas Bailey<sup>8,9</sup> was able to utilize fibrin film successfully as a dural substitute merely by laying it in position and holding it in place by the bony flap, we are dealing with a slightly different condition. The dura, when supported by the skull, is not under any appreciable degree of lateral tension, but in the abdominal wall there is always a residual amount of muscle and fascia pull

which must be maintained in repairing defects with patch grafts of autogenous or foreign materials. In the first four rabbits in which fibrin film was employed to repair abdominal defects (Table III) we disregarded maintenance of abdominal wall tension and the fibrin film proved to be ineffective. In the next four rabbits we tried to maintain the abdominal wall tension by removing a window in the abdominal wall and replacing it with fibrin film of the same dimensions which was sutured in place. None of these rabbits developed wound disruptions although the role that the fibrin film actually played is still obscure. With one exception, the defects were filled by large cysts which had completely encapsulated the film. In the exception a neomembrane of connective tissue had formed in place of the film, which, although quite thin, was strong enough to prevent herniation of the abdominal contents. The encapsulation of the fibrin film represents a typical foreign body reaction, which is not difficult to understand, as the fibrin film contains a protein foreign to the rabbit.

If we prescribe the properties of fibrin film to the four essential qualities originally postulated, we become aware of the following deficiencies, merits and possibilities:

1. Although the fibrin film made available to us produced foreign body reactions in the rabbit, this might be overcome by using fibrin film developed from homogeneous blood plasma. When this has been done, in both man and certain experimental animals, there is a minimum of tissue reaction.<sup>16,17</sup>

2. The fibrin film used by us\* proved very difficult to work with from a technical point of view. It was friable and tore readily unless meticulous care was used. These properties can be modified by varying the conditions under which clotting

\* Our first fibrin film was obtained from Harvard Medical School, on products developed by the Dept. of Physical Chemistry from blood collected by the American Red Cross. Subsequent fibrin film was purchased from Cutter Laboratories.



takes place and by changing the amount and character of the plasticizer present.<sup>8</sup>

3. Although it has been demonstrated that fibrin film is replaced by a smooth sheet of fibrous tissue in homogenous and some heterogenous recipients,<sup>9</sup> it remains to be seen whether it can be used to repair abdominal defects in man.

4. Although the commercially produced fibrin film is expensive, this should not limit its availability once indications for its use have been established.

### CONCLUSIONS

Fibrin film, as it is presently constituted, proved to be unsatisfactory for the repair of abdominal wall defects.

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# CANCER OF THE GALLBLADDER\*

## REPORT OF A FIVE-YEAR CURE OF ANAPLASTIC CARCINOMA WITH METASTASES

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CANCER of the gallbladder can seldom be surgically removed and even when successfully excised by radical technical procedures is not often cured. One is prone to accept the viewpoint expressed by Finney and Johnson<sup>1</sup> that "In many ways, it seems hardly worth while to offer a paper on such a surgically hopeless condition as carcinoma of the gallbladder." To encourage an optimistic surgical attitude, even in the face of metastases from cancer of the gallbladder, we wish to present a unique, long-term survival of a patient with a cancer of high-grade histologic malignancy and with lymph node metastases.

The insidious nature of gallbladder cancer and its low rate of resectability are well recognized. The gradually increasing number of one-, two- and three-year survivals after resection for cancer of the gallbladder and even for contiguous, invaded liver bed, shows considerable progress since Blalock's<sup>2</sup> extensive statistical study in 1924 of 888 cases of biliary tract disease occurring at the Johns Hopkins Hospital from the time of its opening to that date. After his survey of the forty-two biliary cancers, of which twenty-two were primary in the gallbladder, he concluded that "in malignancy of the gallbladder, when a positive diagnosis can be made without exploration, no operation should be performed, inasmuch as it only shortens the patient's life."

The incidence of carcinoma of the gallbladder varies considerably in different series, but the high incidence of 5 per cent in 405 surgically resected gallbladders by Mayo<sup>3</sup> in 1902 (who believed the true pro-

portion to be probably higher) is much greater than we find today. Marshall and Morgan<sup>4</sup> in a study of 1,336 gallbladders removed from 1928 to 1937 found a cancer incidence of 1.4 per cent with a resectability of 20 per cent. Finney and Johnson found carcinoma in 1.5 per cent of 1,192 specimens. Gray<sup>5</sup> in 1934 in surveying 22,365 operations on the biliary tract, found the incidence to be 0.9 per cent, whereas Mohardt<sup>6</sup> in his collected review of the problem placed the incidence at about 0.5 per cent. Cooper<sup>7</sup> in a survey of forty-eight cases seen at the New York Hospital from 1915 to 1935 contrasted the incidence of 3 per cent in 1,500 operations with 0.61 per cent in 2,941 autopsies. Vadheim, Gray and Dockerty<sup>8</sup> found 291 cases of cancer of the gallbladder occurring in 33,500 operations of the biliary tract at the Mayo Clinic from 1907 to 1940 inclusive, an incidence of 0.87 per cent; seventy-seven of these carcinomatous gallbladders could be removed which is a resectability rate of 26.5 per cent. In 29.2 per cent of seventy-five cases metastases to lymph nodes had occurred; in 43.06 per cent direct extension alone had occurred and in 28.2 per cent both means of spread were found. In Lam's<sup>9</sup> series of thirty-four patients six presented lymph node metastases and fifteen direct invasion of the liver. In Cooper's series direct extension to the liver occurred in 66 per cent of the cases and in 52 per cent metastases occurred in the cystic nodes. The progressive and rapid spread of this disease by the time it produces death is shown by the necropsy figures of Kozall and Kirschbaum<sup>10</sup> in which direct liver extension was found in

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fifty-one of fifty-five cases and thirty-four of the same series presented lymph node metastases. One particular finding of Vadheim, Gray and Dockerty seems of special and not too usually recognized significance. They found that 17.3 per cent of their cases presented intravascular involvement by the tumor process. While the most acceptable technics for gallbladder dissection call for preliminary management of the cystic artery and vein, this finding would indicate its necessity in cholecystectomy for cancer in the hope of prevention of spread of the process by tumor emboli.

Sheinfeld<sup>11</sup> has recently summarized the surgical management of cancer of the gallbladder that presented direct extension into the bed of the liver. In thirty-six cases collected in which the gallbladder and the contiguous invaded liver tissue was resected, a total operative mortality of 13.08 per cent occurred. Recurrence in less than one year was noted in 38.08 per cent of the patients and good palliation or possibly good long-term results were secured in 19.04 per cent of these patients. Three were alive at fourteen, fifteen and eighteen months, and one, six and one-half years after operation. He concludes from a survey of these collected cases that liver resection associated with cholecystectomy, if possible, appears to be of definite palliative value. The results, however, are poor when compared with the accomplishments of radical surgery for carcinoma of other organs.

Webber<sup>12</sup> first applied the Broders system of grading to carcinoma of the gallbladder in 1927. In thirty patients with primary carcinoma of the gallbladder, treated by cholecystectomy, the specimen was studied to determine the existence of the relation between the length of life after operation and the grade of malignancy of the tumor removed. Twelve patients with carcinoma, graded II or lower, lived an average of two years and ten months. Fourteen patients with carcinoma graded III or higher, lived an average of 4.8 months. Two patients with carcinoma graded III

or higher were living at that time, one remaining in good health six years and seven months, and the other one year and one month after the operation. Of twelve tumors graded II or lower, four were found at operation to show gross or microscopic evidence of extension or metastases; and of fourteen tumors graded III or higher, thirteen were found at operation to be associated with similar evidence of extension or metastases. In Vadheim, Gray and Dockerty's report, they found 25 per cent of grade I lesions, 64 per cent of grade II lesions, 88 per cent of grade III lesions and 100 per cent of grade IV lesions were associated with metastases. Thus it appears that the frequency of spread beyond the confines of the gallbladder varies directly with the grade of the cancer. In this same study they showed that 45 per cent of the patients with grade I lesions survived five years, one surviving twenty-eight and one-half years. Four and three-tenths per cent of the patients with grade II cancers survived five years and no patients with grade III or IV carcinomas survived to a five-year definitive cure rate. Because of the unique occurrence of carcinoma of the gallbladder of grade III histologic malignancy complicated by lymph node metastases in which the patient has survived for almost eight years since operation, we believe the following case report is worthy of detail:

#### CASE REPORT

R. D., a sixty-four year old, married, white female, was admitted to the Memorial Hospital on July 28, 1941 on the Medical Service of Dr. Lloyd Craver. She had been referred by Dr. Daniel Kornblum who had made a most complete survey of her problem. She complained that her present symptoms began four months previously with an attack of postprandial pain in the right upper quadrant. Several weeks before admission hiccoughing started with aggravation of the pain. She had a gradual loss of appetite and with the anorexia had lost 5 pounds. She vomited only occasionally but there was never blood in the emesis. Before her hospital admission she had begun to have generalized itching and slight

but questionable jaundice. The urine was examined about a week before she was admitted to the hospital and found to contain bile and the icteric index then was 16.6 units. The stools had never shown the presence of blood nor had they been acholic.

There had been a similar attack of pain about twenty years previously which was also worse following meals and also radiated to the right shoulder blade and inferior angle of the scapula. This was entirely managed by dietetic treatment. All other historic data were irrelevant.

Physical examination revealed a woman whose general condition was quite good, but who had a slight icteric tint in the sclera. There were no cervical nodes to be palpated and a pilot node could not be felt. The lungs were clear to auscultation and percussion. The heart was not enlarged and no murmurs were heard. The blood pressure was 110/70. On abdominal examination a firm, irregular, slightly tender mass, the size of a clenched fist, was felt in the right upper quadrant. This was distinctly connected with the inferior surface of the liver and seemed to originate in the region of the gallbladder. The liver itself was not enlarged and there was no other tenderness. There were several small ecchymotic areas on the anterior abdominal wall just below the gallbladder itself. The mass in the right upper quadrant descended with inspiration. Rectal and vaginal examinations were normal.

Laboratory studies revealed the following: red blood cells, 4,800,000; hemoglobin, 93 per cent; white cell count, 7,200, with normal differential distribution. Blood chemical studies revealed serum bilirubin 2.15 mg. per cent; serum protein 7.1 Gm. per cent; sodium chloride 617 mg. per cent. The prothrombin level was 100 per cent of normal. Urinalysis was entirely normal; there was a trace of albumin but there was no evidence of bile.

The x-ray studies had been done by Dr. Daniel Kornblum. On July 24th cholecystograms were done twelve hours after the administration of 7 Gm. of gallbladder dye and there was faint visualization of a mildly enlarged gallbladder. No evidence of calculi was seen and there was failure of the gallbladder to evacuate following a fatty meal. A soft tissue mass measuring approximately 5 cm. across was noted overlying the lower

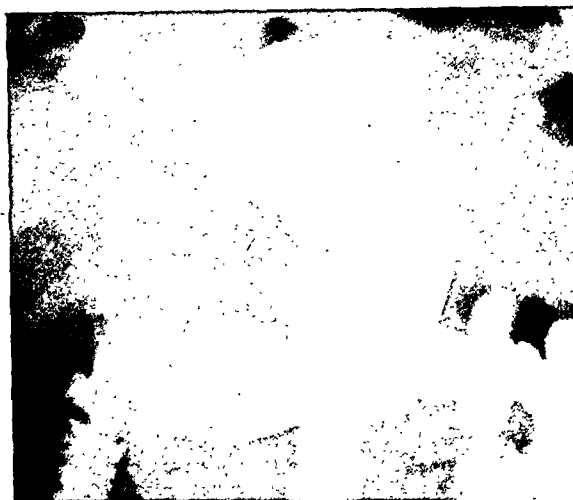


FIG. 1. Photograph of x-rays taken after the ingestion of barium shows the downward and medial displacement of the duodenal bulb and first portion of the descending duodenum.

pole of the liver and on the lower part of it; the mass could be clearly made out but the upper border could not be seen.

The gastrointestinal series showed a normal esophagus and stomach save for spasm in the pylorus and antrum. The shadow previously noted in the gallbladder seemed to be quite closely approximated to the second portion of the duodenum. The duodenal cap and the second portion of the descending portion of the duodenum were displaced downward and medially. (Fig. 1.) However, in about three hours 50 per cent of the barium was still in the stomach and the end of the column was in the terminal ileum. The small bowel pattern was normal.

On barium enema examination no obstruction of the injection was noted in the colon and no polyps or diverticulae were seen. However, in the region of the hepatic flexure there seemed to be fixation of the descending colon around the lower border of the soft tissue mass which was noted in the films of the gallbladder. The mass seemed to be a little larger in the anteroposterior view. After admission to the hospital a repeat fluoroscopic gastrointestinal examination was done without securing additional information. Dr. Lloyd Craver made a tentative diagnosis of carcinoma of the gallbladder.

On July 1, 1941, an exploratory laparotomy was done. Under gas oxygen ether anesthesia a right, upper quadrant, vertical, rectus-splitting incision was made. No free fluid was

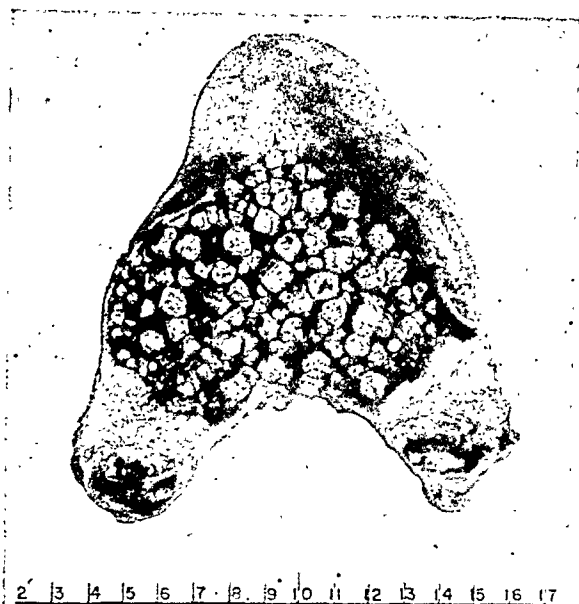


FIG. 2. Photograph of the gallbladder and contained stones. The cancer measures 3 by  $3\frac{1}{4}$  by 3 cm.

found in the peritoneal cavity. The gallbladder was markedly enlarged, measuring approximately 12 cm. in length. After a trocar was inserted into the fundus of the gallbladder, a quantity of pale bile was aspirated. Palpation then revealed a firm indurated area in the region of the ampulla of the gallbladder which, however, was entirely intracystic in nature. Many small faceted stones could be felt after the tenseness of the gallbladder had been relieved. Palpation of the gastrohepatic omentum near the foramen of Winslow revealed a circumscribed, firm round mass, 1.5 cm. in diameter. When the peritoneum over this area was incised and the common duct identified, the mass was seen to be an enlarged lymph node rather than a calculus in the duct as was first suspected. The gallbladder was dissected free from its bed with no great difficulty, save over the region of the ampulla where sharp dissection was necessary to free it from the liver. The cystic duct was dissected down to its entrance into the common duct, sectioned between clamps and the gallbladder removed. The cystic duct was suture-ligated, and then the nodule in the gastrophrenic omentum was enucleated and sent to the laboratory for a frozen section. The report was made of metastatic carcinoma in a lymph node. The common duct was then explored and found to be entirely normal. No stones could be felt upon probing and a small T tube was sutured into

the duct with fine interrupted black silk sutures. Realizing that there was metastatic carcinoma in this region, a complete exploration of the abdominal cavity a second time failed to reveal any further evidence of carcinoma, save that which had been identified after removal of the gallbladder, as arising in the gallbladder itself. The abdominal wound was closed in the conventional manner.

The postoperative course was entirely uneventful, save for the usual T tube drainage, and a rather profuse amount of serosanguineous drainage during the first three days subsequent to the operation. The serum bilirubin by the third postoperative day was 8 mg. per cent, and by the seventh postoperative day was down to 5 mg. per cent; the prothrombin level was 80 per cent of normal. The maximum postoperative temperature was a febrile  $101.2^{\circ}\text{F.}$  on the sixth postoperative day although daily febrile elevations occurred until the tenth postoperative day. Subsequently a normal course was run during the hospital stay which was complete on the twenty-first postoperative day. There was still considerable drainage after removing the common duct tube on the twentieth day after the operation, after having it clamped for several days without any change in symptoms or findings. By September 9, 1941, there was no further drainage from the drain site and the wound was completely healed. Frequent follow-up examinations have been made, and on October 27, 1943, a gastrointestinal series was done which showed an entirely normal duodenal cap without any evidence of spasm or any evidence of duodenal niche. At the time of the patient's last examination on May 31, 1949, she was free of complaints other than those engendered by a mild upper respiratory infection. No pilot nodes could be found. The examination of the abdomen presented no enlargement of liver or spleen, and rectovaginal-abdominal examination was entirely negative. The patient did note, however, that she felt much better when she was on a fat poor, high protein diet.

The pathologic report No. 0-1868, by Dr. Fred Stewart, was as follows: "The gallbladder in its unopened state measures 15 by 7 by 6 cm. On palpation the fundus of the gallbladder feels as though it was filled with stones. The proximal portion near the line of transection is very firm. There appears to be a mass involving this part of the specimen, which



FIG. 3. A, photomicrograph of the gallbladder wall showing complete infiltration by the adenocarcinoma. Histologic grade of malignancy, III; B, photomicrograph of one of the two lymph nodes showing complete replacement of nodal architecture by the adenocarcinoma.

measures approximately 6 by 4 by 4 cm. The specimen is sectioned in the longitudinal plane. The fundus is completely filled with approximately 200 faceted gallstones. No bile is present in the gallbladder. The wall is somewhat thickened in the proximal portion of the specimen. There is a firm, pinkish-yellow lesion which measures 3 by  $3\frac{1}{2}$  by 3 cm. It is completely angular and apparently blocks off the cystic duct. The cystic duct is dilated. There appears to be a narrow margin of normal tissue at the line of transection. (Fig. 2.) The mass has the appearance of tumor tissue. The second specimen consists of two lymph nodes, one measuring 2 by  $2\frac{1}{2}$  by 2 cm., the other measuring 1 cm. in diameter, both of which, on cut section, appear to be lymph nodes replaced with tumor tissue." Microscopic diagnosis of the lesion in the gallbladder was an adenocarcinoma of grade III histologic malignancy, chronic cholecystitis. (Fig. 3A.) Microscopic examination of the two

lymph nodes was reported as showing metastatic adenocarcinoma. (Fig. 3B.) The final diagnosis was chronic cholecystitis with cholelithiasis; adenocarcinoma of the gallbladder, grade III with metastases to regional lymph nodes.

#### SUMMARY

1. A case report is given of cancer of the gallbladder of high-grade histologic malignancy with regional lymph node metastases. The patient has survived cholecystectomy and dissection of the cystic nodes for nearly eight years.

2. Despite marked anaplasia and regional node metastases, cancer of the gallbladder is a curable disease and an attempt to control this cancer is always in order.

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IN 1775 Percival Pott described scrotal cancer occurring in chimney sweeps and correctly suggested that the accumulated soot apparently had a cancer-producing effect in these particular subjects. Recently we discovered that workers on fluorescent watch dials died of "radium disease" as did miners working with radioactive ores. In addition to these radioactive elements we now know that chemical and parasitic factors may equally well produce cancer, especially in "susceptible" individuals. The better known *physical agents* apparently capable of producing cancer under proper conditions are: X- and gamma rays, ultraviolet, beta and alpha rays. The commonly known *carcinogenic inorganic chemicals* are: asbestos, possibly beryllium, arsenic, nickel carbonyl and the chromates; also these *organic chemicals*: benzol, polycyclic hydrocarbons, soot, benzol, aromatic amines, carbon black, paraffin and shale oils, certain types of mineral oils, anthracene oil, tar and pitch, and creosote. Undoubtedly, under certain conditions, the estrogens, the azo dyes and the aniline dyes also have carcinogenic properties. The *parasitic agents* that occasionally seem capable of producing cancer are the viruses. In fact, I believe the viruses will eventually be found to be the most common cause of cancer. Other parasitic agents that should be mentioned in this connection are schistosoma hematobium and, possibly, clonorchis sinensis. (Richard A. Leonardo, M.D.)

# MINIMAL SADDLE-BLOCK ANESTHESIA FOR VAGINAL DELIVERY\*

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THE injection of certain drugs into the spinal canal to obtain anesthesia has been in use since Corning first reported such a procedure in 1885. In the ensuing years a constant search for a safe drug and a controlled level of anesthesia has been made. Agents used included cocaine, procaine, pontocaine, metycaine, nupercaine and many others. The procedure firmly established itself as a safe and satisfactory method for general and gynecologic surgery but an attempt to adopt it to obstetric cases was soon followed by reports of shock, intra-uterine fetal asphyxia and sudden death of the parturient. Greenhill<sup>1</sup> as recently as 1946 stated that spinal is the most dangerous of all anesthetics for the pregnant woman. In 1941 Hingson and Edwards<sup>2</sup> introduced continuous caudal anesthesia to abolish the pains of labor and parturition; since their original report, over 100,000 cases have been recorded. However, the requirements of a specially trained anesthetist in constant attendance, the frequent failures due to sacral anomalies and the sudden deaths resulting from injections into the subdural space have greatly dimmed the earlier enthusiasm for this procedure.

Pitkin<sup>3</sup> in 1928 demonstrated spinal anesthesia localized to the perineal region but his results were somewhat unsatisfactory due to uncertain dispersion of the drug. In 1935 Sise<sup>4</sup> utilized pontocaine in a glucose vehicle and was able to localize the hyperbaric solution to any desired level. Adriani and Roman-Vega<sup>5</sup> in 1946 reported a simplified technic using nuper-

caine in 10 per cent glucose solution; Parmley and Adriani<sup>6</sup> reported 136 deliveries conducted under saddle-block anesthesia with the same agents. The term saddle-block was aptly chosen by Adriani to describe a form of low spinal anesthesia confined to the perineal region. The hyperbaric nature of the mixture causes it to gravitate downward about the conus and the concentration of the drug can be varied by the time the patient remains in the upright position. The use of the term saddle-block enables the obstetrician to avoid any reference to the spine and the procedure is readily accepted by many patients who harbor unreasonable and unfounded fears of a spinal anesthetic.

In 1946 the use of pontocaine-glucose low spinal anesthesia to abolish the pains associated with vaginal delivery was initiated at this hospital. Over 900 such anesthetics utilizing 6 mg. of pontocaine in 10 per cent glucose were administered very satisfactorily with no serious untoward results. In the latter months of 1947 an attempt was initiated to determine the minimal dosage of pontocaine which would still give satisfactory anesthesia. A reduction to 4, then 3 and finally 2 mg. was made. A trial with 1½ mg. revealed that amount to be insufficient in most cases. From December 4, 1947 through October 15, 1948, there were 1,522 vaginal deliveries performed on our service. Of this number 1,000 were delivered under a 2 mg. pontocaine saddle-block anesthesia. It is with that technic that this report is concerned.

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## SELECTION OF CASES

This series is consecutive and includes all saddle-block anesthetics given during the period covered by the report. The choice of cases for this type of anesthesia was liberal and included such prenatal complications as:

Pre-eclampsia mild.....	70
Pre-eclampsia severe.....	9
Pyelonephritis.....	10
Syphilis (all treated).....	10
Cardiacs.....	2
Diabetes.....	1
Marginal placenta praevia.....	2
Abruptio-placenta slight.....	5
Chronic nephritis.....	2
Lobar pneumonia.....	1
Benign hypertension.....	4
Asthma.....	2
Tuberculosis, pulmonary.....	2
Sickle cell anemia.....	1
Carcinoma of the breast.....	1
Hypoglycemia with convulsion.....	2
Neisserian infection, acute.....	1
Renal calculus.....	1
Hyperthyroidism.....	1

The usual contraindications to any spinal anesthetic were observed plus the special obstetric ones of certain abnormalities of presentation, anticipated intra-uterine manipulation, placenta previa and abruptio placenta when accompanied by marked blood loss, and certain cases were deemed unsuited psychologically for this type of anesthetic. Some breech deliveries are included although we prefer to perform breech extractions under general anesthesia to obtain uterine relaxation and other breech deliveries under pudendal block so as to retain the optimum assistance of the maternal expulsive forces.

There were 501 multiparae and 499 primiparae of whom twenty-one were negro; the remainder were caucasian. Ages ranged from sixteen to forty-four years. The majority of the anesthetics and deliveries were performed by interns and residents under the supervision of the senior staff members.

## ANALGESIA

Analgesia during the first stage of labor and the second stage up to the administration of the saddle-block has been obtained

by the use of seconal, demerol and scopolamine. Seconal ( $1\frac{1}{2}$  to 3 gr.) is given orally when labor is progressing satisfactorily, the head engaged and the cervix effacing and dilating. This is usually 3 cm. in the multiparae and 4 cm. in the primiparae. One-half hour later demerol (100 mg.) and scopolamine ( $\frac{1}{200}$  gr.) are administered hypodermically. The scopolamine is repeated as needed and the demerol may be repeated if delivery is not expected to occur within the next hour. The results obtained with this program have been highly satisfactory; 82.3 per cent of the patients received routine analgesia.

## TECHNIC

The time of administration of the saddle-block is upon full dilatation of the cervix with the presenting part starting to crown or to any patient when it is believed that the time to terminate the labor has arrived. This practice does not conform to that of several institutions where a larger dose of anesthetic agent is administered during the first stage of labor. The fact that such cases must be followed very closely by trained personnel limits the practicability of that technic to a few of the larger teaching centers. That this delay is not without benefit is shown by the increased incidence of occiput transverse and persistent posterior position in several recently reported series. Dieckmann<sup>7</sup> shows 7.8 per cent occiput transverse and 7.6 per cent occiput posterior while Jorgensen, Graves and Savage<sup>8</sup> show 14.8 per cent occiput transverse and 12.6 per cent occiput posterior. In our series the incidence of persistent occiput transverse positions was 6.7 per cent, of occiput posterior, 7.1 per cent.

When a patient is ready for delivery, she is placed in a sitting position in the center of the delivery table. Her arms are folded across the abdomen and an assistant supports the shoulders as she leans forward. The nurse prepares the back with ether followed by tincture of merthiolate. Using sterile technic the anesthetist draws 0.2 cc. (2 mg.) of 1 per cent pontocaine solution,

then 1.0 cc. of 10 per cent glucose into a Luer-Lok syringe and gently agitates the mixture. A spinal puncture is then performed using a twenty-two gauge short bevel needle between either the fourth or the third lumbar interspace. As soon as a free flow of spinal fluid is detected, the syringe is connected and the anesthetic solution is injected with moderate pressure using three seconds for the timing. Time is started on the sweep second hand of the clock. At ten seconds the spinal needle is withdrawn; at forty-five seconds the patient is placed flat on her back. The injection should be made between pains as it might otherwise ascend to an undesirably high level. If the fluid is bloody or if no fluid is obtained, the anesthetic is not injected and some other type of anesthesia is used. In the interests of the baby a continuous oxygen flow is administered through a mask strapped over the patient's face, this being started immediately after administration of the anesthetic and continued until the cord is severed.

It has been demonstrated that the sensory fibers from the uterus enter the eleventh and twelfth thoracic segments and those from the cervix, vagina and perineum enter the second, third, and fourth sacral. The motor fibers to the contractile portion of the uterus originate at a higher level, probably the fourth to twelfth thoracic. The sensory fibers of a mixed nerve are more susceptible to an anesthetic agent than are the motor ones and while the majority of the drug is localized about the conus, some diffusion occurs upward. Following the intraspinal injection of the pontocaine-glucose solution complete anesthesia and motor paralysis of the perineal region, anesthesia of the inner thighs and hypalgesia of the remainder of the legs results; the patient retains her ability to move the legs and hips. Some of the solution diffuses high enough to block the sensory fibers to the uterus, abolishing the pain of contraction without markedly impairing the uterine contractions themselves. The muscles of the abdominal wall are not

involved and the patient is able to bear down upon request.

#### RESULTS

In our series we classified results obtained from the saddle-block as excellent, good and failures. Those patients whose results were classified as excellent were able to raise their hips before and after delivery and were able to move from the delivery table without assistance. They had loss of painful sensations from both the lower birth canal and from the uterine contractions and there was complete perineal relaxation. Forceps pull was experienced as a sensation of pressure. Classified as excellent were 86.9 per cent of the cases. Those patients whose results were classified as good had complete anesthesia and relaxation of the perineum but felt some painful uterine contraction or had motor paralysis of the legs and hips; these constituted 12.8 per cent of the cases. Three patients had some anesthesia but it was of such short duration that a supplementary agent was required; these were classified as failures. In two cases blood was obtained when the stylet was withdrawn and in two no fluid at all; the pontocaine-glucose solution was not given to the latter four. The corrected failure percentage is thus 0.3 per cent.

The duration of anesthesia was no shorter than one hour in any successful case and the average was from one and a half to two hours. The weight, size and age of the patient did not influence the duration.

The maternal blood pressure was recorded prior to administration of the saddle-block every five minutes during the delivery and one hour postpartum. In 83.1 per cent of the patients there was no change or a fall of less than 10 mm. of the systolic readings; 8.3 per cent sustained a fall of from 11 to 20 mm., 1.5 per cent from 20 to 30 and in one patient the fall was 36 mm. In seven patients the systolic pressure fell to below 90 mm. and in one to below 80 mm. All of these promptly rose to satisfactory levels following the adminis-

tration of  $\frac{3}{4}$  gr. of ephedrine sulfate. In no case was the duration of fall longer than five minutes nor was the fetus adversely affected. In only eight cases was it deemed necessary to administer vasopressor therapy. Seventy-one patients sus-

patients. Manual removal was performed in any case in which the placenta was retained for one hour or whenever indicated by blood loss regardless of the time.

As depicted in Table II, the blood loss was less than 300 cc. in 97.5 per cent; it

TABLE I  
POSITION AND DELIVERY

Mode of Delivery	Fetal Position						
	O. A.	O. P.	O. T.	Breech	Brow	Face	Total
Spontaneous.....	248	8	..	1	..	1	258
Low forceps.....	653	31	22	..	1	..	707
Mid forceps.....	3	9	15	..	..	..	27
Manual rotation.....	..	6	14	..	..	..	20
Forcep rotation.....	..	17	23	..	..	..	40
Manual assist.....	..	..	..	9	..	..	9
Extraction.....	..	..	..	4	..	..	4

tained a rise in systolic blood pressure ranging from 10 to 40 mm. In the majority of these the pregnancy was complicated by pre-eclamptic or hypertensive toxemias.

Fetal positions and the incidence of operative deliveries were not influenced by the saddle-block anesthetic as it was administered only when delivery was imminent. We routinely use outlet forceps and perform an episiotomy on practically all primiparae and many multiparae. Table I shows the fetal position and the method used for delivery.

Proper management of the third stage commences with slow delivery to the anterior shoulder at which time pituitrin ampule one is administered subcutaneously to the mother and the baby's respiratory passages are carefully aspirated. After a delay of about one minute the baby is extracted and the cord is cut and ligated. As soon as the position and consistency of the fundus reveals that the placenta has separated spontaneously, it is expressed and ergotrate ( $\frac{1}{320}$  gr.) is injected by vein. The duration of the third stage was less than five minutes in 75.6 per cent of the cases, under ten minutes in 92.6 per cent, and thirty to sixty minutes in only eight

was over 500 cc. in only three cases, two due to retained placenta and one due to uterine atony.

Postpartum care of the patients was essentially symptomatic. We employ early ambulation; twelve hours after delivery the puerperal woman is permitted to walk to the bathroom unless contraindicated by the presence of toxemia or blood loss or if undesired by the patient. All but sixty-four of the patients followed this regimen. Some of the patients (3.5 per cent) complained of vertigo or faintness on arising for the first time; 3 per cent of the patients were nauseated or vomited. Catheterization was required on one or more occasions by 2 per cent of the patients. The majority of those necessitating repeated catheterization were in the major operative delivery group. Enemas were administered to 2.5 per cent of the patients. The low incidence of catheterizations and enemas was undoubtedly due in part to our policy of early ambulation.

Headache upon arising, usually occurring on the first or second postpartum day, is the outstanding complaint of patients who have delivered under saddle-block anesthesia. While some undoubtedly were due

to unrelated causes such as eye strain, fever and elevated blood pressure, we included in this "spinal headache" group every patient who complained of a postpartum headache regardless of the presence of other possible causative factors. This

TABLE II  
THIRD STAGE OF LABOR

Delivery of Placenta		Duration		Blood Loss	
(type)	(no.)	(min.)	(no.)	(cc.)	(no.)
Spontaneous.....	13	0-5	756	0-100	459
Crede modified .....	240	5-10	170	100-200	463
Brandt-Andrews .....	733	10-15	42	200-300	53
Manual removal.....	14	15-30	24	300-500	22
		30-60	8	500 and over	3

was done so as to not minimize in any way the frequency and importance of this major subjective complaint of the patients. All headaches persisting more than two days or those forcing the patient to remain in bed, were classified as severe; all others were termed mild. Two hundred four (20.4 per cent of the patients complained of headache; of these seventy-seven were classified as severe. There were no intractable cases and no patient was forced to remain in the hospital for any additional time because of headache.

Eighteen patients complained of pain in the back. These varied in location, were of short duration and were relieved by aspirin and heat. They probably were positional and not due to the lumbar puncture.

#### MORBIDITY

Morbidity in the puerperal woman has been defined as two consecutive days excluding the day of the delivery on which the temperature rose to 100.4°F. or above. Under this standard we had thirty-one (3.1 per cent of the patient) morbid cases for a total of eighty-six patient days. The longest case was one of severe Vincent's stomatitis of six days' duration. With the increased use of prophylactic penicillin and sulfonamides in patients with early rupture of the membranes, manual invasion of the uterus and major operative deliveries, the

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old standards for morbidity need a revision downward. With this in mind, we designated as febrile all patients who sustained a temperature elevation to 99.4°F. on any two successive days not counting the day of delivery but who did not attain suffi-

TABLE III  
PUERPERAL MORBIDITY AND FEBRILITY

Cause	Morbid*		Febrile†	
	No. of Patients	Days	No. of Patients	Days
Puerperal infection.....	23	64	41	123
Episiotomy infection....	.....	..	26	67
Urinary tract infection..	2	4	13	48
Upper respiratory infection.....	.....	..	6	16
Breast infection.....	.....	..	6	13
Vincent's stomatitis.....	1	6	2	7
Malaria.....	1	3		
Infectious mononucleosis.	1	5		
Cellulitis, buttock.....	1	2		
Gastroenteritis.....	1	2	1	2
Postpartum tubal ligation.....	.....	..	1	2
Reaction to blood transfusion.....	.....	..	1	2
Cause not determined...	1	2	42	107
Total.....	31	88	139	387
Per cent.....	3.1	..	13.9	

\* 100.4°F. or above for two consecutive days.

† Over 99.4°F. but under 100.4°F. for two consecutive days.

cient elevation to be classed as morbid. One hundred thirty-nine (13.9 per cent) of the cases were so classified. Table III shows the cause and duration of all the morbid and febrile cases in this series.

#### DELIVERIES

There were 1,005 infants delivered including forty-seven prematurely and five sets of twins. Nine hundred seventy-six of these babies breathed spontaneously in less than one minute, many of them making respiratory attempts even prior to delivery of the trunk. The initial respiration was delayed longer than three minutes in only

eight cases. Seventeen infants required resuscitation. (Table iv.)

There were eight stillborn babies in this series; in six of these fetal death was diagnosed prior to the administration of the saddle-block. Five of the mothers suffered

TABLE IV  
INITIAL RESPIRATION OF BABY

	Babies	Per cent
Breathed in less than 1 minute....	976	97.9
Breathed in 1 to 3 minutes.....	13	1.3
Delayed over 3 minutes.....	8	0.8
Resuscitation required.....	17	
Stillborn.....	8	
Total.....	1,005	100.0

from moderate or severe toxemias and one had just passed the crisis of lobar pneumonia. In the remaining two the condition of the fetus seemed normal at the time of the administration of the anesthetic but the fetus was stillborn. In one a 12 pound fetus died because of shoulder dystocia after the head was born. In the remaining case, a 3 pound premature infant, the fetal heart tones suddenly ceased during the second stage of labor. There was no fluctuation in the maternal blood pressure following the intraspinal injection in this patient. Therefore, we can attribute no stillbirths to the use of the saddle-block anesthetic.

Eleven babies died during the neonatal period. Three of these succumbed to major congenital deformities incompatible with life and demonstrated at autopsy. Four were premature babies, all weighing under  $3\frac{1}{2}$  pounds and revealing congenital atelectasis at postmortem examination. One, weighing 4 pounds 15 ounces, died of intracranial hemorrhage following a precipitate spontaneous delivery complicated by abruptio placentae. In two cases complicated by pre-eclampsia and polyhydramnios, the initial fetal respirations were delayed and resuscitation was required. Each of these babies showed respiratory difficulty and

died within twenty-four hours. No autopsies were permitted but the clinical picture was that of atelectasis. One baby breathed spontaneously following a normal labor and delivery but was found dead in its crib eight hours after delivery. Autopsy showed atelectasis with bronchial obstruction from a mucous plug.

The maternal systolic blood pressure did not fluctuate over 10 mm. of mercury nor fall below 100 in any case of stillbirth or neonatal death.

#### COMMENTS AND CONCLUSIONS

The use of saddle-block anesthesia produced by the intraspinal injection of 2 mg. of pontocaine in a vehicle of 1 cc. of 10 per cent glucose solution affords a safe and efficient anesthetic for vaginal delivery. The technic is simple and, if certain safeguards are observed, the method is without danger to either the mother or the fetus. With the use of suitable analgesic agents during the first and second stage of labor, the anesthetic may be withheld until the time for delivery has arrived. This allows the normal course of labor to proceed without disruption of the established hospital routine and does not throw any additional work upon the nursing and resident physician staff.

The maternal blood pressure is not noticeably affected in the majority of the patients. In a small number there is a fall which is believed to be due to the abolition of the painful uterine contractions and the associated fears. In the exceptional case the systolic pressure will fall to below 90 mm. but such patients respond rapidly to parenteral administration of ephedrine sulfate and in this series no patient was cause for concern on the part of the anesthesiologist. Those patients exhibiting the vasomotor instability associated with toxemias of pregnancy reveal a tendency to an elevation of the systolic pressure at the time of delivery despite the presence of the saddle-block anesthetic. However, adequate first and second stage analgesia helps to minimize this rise.

Under saddle-block anesthesia the contractility of the uterine musculature is not impaired and there is a resultant shortening of the third stage with a diminution of the blood loss. The advantage of this saving of blood to the parturient is obvious and is reflected in the low morbidity rate among the cases in this series.

Upper respiratory complications are rare in patients who deliver under saddle-block in marked contrast to those on whom any type of inhalation anesthesia is used. Patients with pulmonary disease tolerate this anesthetic with no adverse effects and cardiac patients actually may be benefited by the abolishment of the bearing down forces with their resultant increase in intra-abdominal pressure.

The normal function of the urinary and gastrointestinal systems is quickly restored after parturition under saddle-block anesthesia and few patients will need either catheterization or enemas. The practice of urging the uncomplicated patient to rise and attempt to void twelve hours after parturition is well rewarded by the low incidence of catheterization needed and the infrequent occurrence of puerperal urinary tract infections.

The high incidence of postspinal headaches is the one objectionable feature encountered with this technic. Its actual frequency and severity are difficult to assess because of the strong element of suggestion which is present and its occurrence in one ward patient was always soon followed by several others in nearby beds. The cause of spinal headache has not been determined and the use of a small gauge needle for the puncture, the careful removal of antiseptic agents from the skin before its performance and delay in withdrawing the needle after making the injection have all failed to decrease the incidence. Some of the patients revealed a hypotension with their headaches, some of which could be relieved by wearing tight abdominal binders. Most of the headaches appeared on the first or second postpartum day and usually disappeared in two or three

days. As soon as a patient complains of a headache, she is placed on a regimen consisting of ephedrine sulfate ( $\frac{3}{8}$  gr.) three times daily, tight abdominal binder, high fluid intake and nicotinic acid 100 mg. three times a day. The latter drug is given with the hope of increasing the cerebral blood supply but its efficacy is doubtful. No patient has remained in the hospital beyond her expected discharge date because of headache and none complained of headache upon discharge.

The maternal morbidity in this series is below that usually reported. This is believed to be due in part to the prophylactic use of antibiotics, and often the sulfonamides, in all patients with early rupture of the membranes, prolonged labor, pre- and intrapartum fever and those undergoing major operative procedures. Credit must also be given to the lessened incidence of upper respiratory complications and urinary tract infections.

We have adopted the use of the term febrile to designate those cases in which temperatures are elevated above normal but are not high enough to be classified as morbid. We believe that such a critical analysis gives a much more accurate picture of the incidence of postpartum complications. Obviously with such a narrow margin between the normal and the abnormal, there will be an increased number in whom the cause of febrility cannot be determined.

The condition of the baby when delivered under saddle-block anesthesia is a revelation to anyone not accustomed to its use. These babies are pink, wide awake and breathe and cry without delay. The unresponsive blue baby so typical of the transplacental narcosis which is often seen when the mother has received inhalation anesthetics for delivery is seldom encountered in these patients and resuscitation is rarely employed. In no case did we believe that the intrapartum or neonatal death was in any way attributable to the saddle-block anesthetic. The continuous administration of oxygen to the mother during

delivery is a worthwhile safeguard to improve fetal oxygenation.

Fetal position is unchanged by saddle-block anesthesia as used in this series and the duration of labor is unaffected. The incidence of operative deliveries is not increased as the mother is able to bear down upon request.

The total gross fetal mortality in this series was nineteen (1.9 per cent); eight (0.8 per cent) stillbirths and eleven (1.1 per cent) neonatal deaths. Three of the neonatal deaths occurred from congenital abnormalities incompatible with life, giving a corrected neonatal death rate of eight (0.8 per cent); of these eight, four of the infants weighed less than  $3\frac{1}{2}$  pounds. It is our opinion that no fetal death could be attributed to the saddle-block anesthesia.

There were no cases of phlebitis, none of any neurologic sequelae, except one transitory Bell's palsy, and no maternal deaths in this series of 1,000 women who delivered

under a 2 mg. pontocaine saddle-block anesthetic.

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# INTERNAL FIXATION OF FRACTURES OF THE FEMORAL NECK\*

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THIS paper reports the results obtained by internal fixation of fractures through the femoral trochanters, neck and subcapital region over a ten-year period, from 1935 through 1945, on the Second (Cornell) Surgical Division of Bellevue Hospital. The bulk of the fixations (121) were accomplished by Smith-Petersen nailings although there were a number (6) of Moore pinnings of both, transcervical and intertrochanteric fractures, and one Moore-Blount nailing of an intertrochanteric fracture.

There have been a number of papers reporting similar series, but there have been only a few which attempted to give detailed analysis of the results obtained. Most authors have described their technic, given their criteria for operability and contented themselves with stating the percentage of bony union obtained. If the results were classified, it was without a clear definition of what was meant by good, fair and poor results. Since the most important factor in evaluating the worth of an operative procedure is the end result, we believe that it is valuable to report a comparatively large series with an exact grouping of the cases as to their functional result.

The results reported in this series may be taken as a good indication of the efficacy of the Smith-Petersen nailing in the hands of a general surgeon who is thoroughly familiar with the technic but is without the extensive operative experience that the orthopedic surgeon should possess. The vast majority of the operations reported were performed by members of the house staff. Their first assistant was usually an attending surgeon, and the roentgenograms

were taken by a member of the house staff rather than by an x-ray technician. In a few of the earlier instances the procedure was performed by a member of the senior staff.

## HISTORY

The nailing of transcervical femoral fractures had its beginning in the work of Smith-Petersen, Cave and Vangorder<sup>1</sup> in 1931. They employed the Smith-Petersen anterior approach to the hip joint and inserted the three-flanged nail devised by Smith-Petersen under direct vision. Post-operatively, the patients were placed in Whitman spicas at first, but after the operators' confidence mounted they suspended them in traction. Hip exercises were undertaken at the end of three weeks, and the patients bore weight in abduction in a bivalved short spica shortly thereafter. They reported twenty cases of union in 75 per cent, non-union in 15 per cent and death in 10 per cent. It is interesting to read that the nail was occasionally misplaced despite nailing under direct vision. The results in this first series were as good as the average reported since although the benefits of early mobilization were not yet available to the patients.

How good these results were in comparison with those obtained by the previously accepted method of treatment is seen by the figures given by Speed.<sup>2</sup> He treated one hundred patients with transcervical fractures with Whitman spicas and got 52 per cent bony union, excluding deaths. He quotes Willis C. Campbell as having 53 per cent bony union and a mortality of 12 per cent in a large series treated with a spica. In 1929 the American Ortho-

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pedic Association reported a review of results from leading clinics. The average bony union was 50.4 per cent and the average mortality was 29 per cent. In the same article Speed<sup>2</sup> explained the phenomenon of union with a necrotic head followed by fragmentation of the head at a later date by showing microscopic sections revealing new bony trabeculae crossing the fracture line into a necrotic head.

H. Heyward Westcott<sup>3</sup> was the first to employ a subtrochanteric incision in the Smith-Petersen nailing. He used protractors and anteroposterior roentgenograms to guide the nail. Then Sven Johannsen<sup>4</sup> described the use of a cannulated three-flanged nail introduced over a Kirschner wire. This was a distinct improvement because, in a sense, it enabled the operator to check the position of the nail before it was inserted since the nail would follow the wire. However, Johannson used a complicated and unhandy radiographic control.

Smith-Petersen adopted the subtrochanteric incision and published his new technic in 1937.<sup>5</sup> He did not use a guide wire but employed the Westcott protractor and a calibrated marker which was placed on the skin just above the femoral neck. An anteroposterior film then gave the length of the nail desired. He advocated use of the Leadbetter reduction rather than the previously employed Whitman method for reduction under anesthesia on the operating table. It was recommended that the nail be centered in the neck and head, and four weeks of postoperative traction was advised.

Rankin<sup>6</sup> reported a series of seventeen cases with a 12 per cent hospital mortality and an 87 per cent bony union (excluding deaths), using the Smith-Petersen subtrochanteric technic. He pointed out that a great danger in nailing subcapital fractures was the possibility of rotation of the head during insertion of the nail. Campbell<sup>7</sup> used the same technic and had bony union in all of his nineteen patients, but there were late changes in the head in two instances. There were fifty patients in Harris's series<sup>8</sup> with

bony union in 80 per cent (excluding deaths) and a 10 per cent mortality rate.

In 1943, Carothers and Giannestras<sup>9</sup> wrote a paper classifying their results functionally as well as with respect to bony union. The hospital mortality was 7 per cent, the average age was sixty-seven years and 80 per cent were females. Excluding deaths, 78.6 per cent had bony union. There were 55 per cent excellent, 24 per cent good, 12 per cent fair and 9 per cent poor results. They also expressed the belief that if the nail is properly placed early weight-bearing is not a disadvantage. Their patients began three-point weight-bearing ten days postoperatively and increased the degree of weight borne gradually until union had occurred. In the published discussion following this paper Dr. William Darrach pointed out that a walking Thomas splint is not good treatment for a healing transcervical fracture because the fracture site is made to act as the fulcrum in the walking motion.

Earlier Cleveland<sup>10</sup> had stated his belief that getting those with nailed hips out of bed in the immediate postoperative period was a stunt which served no useful purpose. He reported a series of seventy-two patients surviving the operation with bony union in 83 per cent. The mortality rate was 15 per cent. He also expressed his belief that almost all aseptic necroses of the head can be detected within the first postoperative year.

Experience with internal fixation on our sister service at Bellevue was reported by Siris and Ryan<sup>11</sup> in 1944. They discussed the dangers of prolonged immobilization in the elderly, the importance of good nursing care so often missing in charity hospitals and the hazards of cystitis, incontinence, decubitus ulcers, sepsis, thrombophlebitis and hypostatic pneumonia incidental to long immobilization. They seemed to express these indications for nailing and early rising more effectively than other authors. This may have been because patients were admitted to their service in the same state of physiologic

disrepair as were our own. The causes of the unfortunate physical condition of these patients were (and are), alcoholism, chronic malnutrition, drug addiction and so forth. These authors realized better than most the dangers of prolonged immobilization because their patients were less able to resist them.

They expressed their belief in immediate nailing if the patient seemed able to withstand the operative procedure, believing that preoperative traction accomplished nothing. It was believed that in very feeble individuals the operation should be done under local anesthesia with no attempt at complete reduction, providing the existing reduction was "75 per cent complete." This was thought to be the best compromise between the great danger inherent in non-operative treatment of the fracture and the almost equal hazard of a general anesthesia in such debilitated individuals.

Advantages of the three-flanged nail were reviewed by Siris and Ryan and were stated to be: (1) The flanges permit no rotatory motion; (2) the length prevents angulation; (3) there is minimal bone displacement; (4) there is maximal surface contact.

Their technic is very similar to that employed in the majority of cases reported in this series. Unfortunately their results in the Smith-Petersen nailings were not stated in a definitive fashion.

The intertrochanteric fractures were treated by a variety of methods with an overall mortality rate of 22 per cent. This relatively high mortality was attributed to the greater comminution and shock accompanying this injury. Moore pins, external pin fixation, Smith-Petersen nails with a Hawley Bar and Moore-Blount nails were the means of operative fixation employed. Siris and Ryan preferred the Moore-Blount nail, believing that there was too great a danger of comminution when using the Smith-Petersen nail. Their patients with external pin fixation all became infected at the pin sites and died. The Moore pins

frequently did not hold the fragments well coapted so that healing could take place.

Swart and Miyakawa<sup>12</sup> reported a detailed analysis of the results in thirteen patients with Smith-Petersen nailings. They were: three, excellent; 4, good; 2, fair and 3, poor. An excellent result was one in which there was no pain, stiffness or other symptoms, and a good result had some stiffness and pain but no limp. There was aseptic necrosis of the head in two cases, followed by painful ankylosis in one. One death occurred from an embolism twelve hours postoperatively.

A good description of the roentgenographic criteria for an adequate reduction of femoral neck fractures is in an article by McElvenny.<sup>13</sup> He thought that at the completion of the Leadbetter reduction the patella should face directly medialward, with the lesser trochanter barely visible in the anteroposterior film. Any overlap detectable in the anteroposterior or lateral films following reduction means inadequate reduction and the nailing should be postponed. Almost all failures, in McElvenny's opinion, are caused by inadequate reduction and he believes that if adequate reduction cannot be obtained immediate intertrochanteric or subtrochanteric osteotomy should be performed. Following roentgenographic proof of reduction, the nail should be inserted at, or below the level of the lesser trochanter, and should traverse the lower half of the neck parallel to the calcar femorale, centering the head in both planes. He emphasized that the nail should be placed in the weight-bearing line, acting as a guide to deliver the head into proper position on the neck. In the later cases in our series the nail was placed in the valgus position because of similar reasoning.

A number of mechanical devices have been devised to facilitate this operation. Among the seemingly more practical of these devices is the cannulated screw<sup>14</sup> with threads only at the tip and a slot to drive a flange in after the screw is in position. This

flange is known as the "key." A device to aid blind nailing was described by Crecca and Cetrulo.<sup>15</sup> It aids in procuring the angle of inclination to the center of the head from the site chosen for insertion of the nail. The pin can then be inserted in the same direction. There has not been experience on the Second (Cornell) Surgical Division at Bellevue with such devices, and we think that they are not reliable and only complicate matters. They no doubt can be used to advantage by their inventors.

The history of internal fixation of fractures about the femoral neck and trochanters would not be complete without mention of the great step forward in the adoption of Vitallium nails and pins following the research of Venable and Stuck.<sup>16</sup> They ascertained that this cobalt, chromium and molybdenum alloy was inert in body tissues. The stainless steel devices previously in use frequently gave rise to a collection of fluid about themselves, followed by an electrolytic absorption of the bone. Vitallium, being inert in body fluids, does not electrolyze and absorption does not take place. There is now no necessity to remove the nails and pins as a prophylactic measure against such absorption.

#### TECHNIC

The patient is taken to the operating room in a Thomas splint if reduction has been obtained by Russell traction. A suitable strap should be placed to prevent external rotation of the foot. The traction should be approximately equal to that employed to achieve the reduction. The patient is then placed on a standard operating table with a wooden cassette holder in its center. The remainder of the table is built up to the patient with pillows.

Two portable x-ray machines are placed, one to show the anteroposterior view of the fractured hip on the cassette in the wooden holder, and one placed to take lateral views according to the Manfredi technic. The tube is put at table level beside the knee of the uninjured side and

this leg is now bound to the top of the tube to remove it from the field. With the tube aimed at the fractured hip and a cassette held against the greater trochanter from above, lateral films may be procured. One of the greatest difficulties encountered in these nailings has always been the inadequate lateral films obtainable with the portable machine. This can be obviated if a Lyscholm stationary grid is used for the lateral film. In this event the exposure time should be 4 times that usually employed.

The leg is now gently removed from the Thomas splint with the traction maintained by an assistant. The operator then gently abducts the leg and flexes the knee until the patient's foot rests on a stool beside the table. *Traction and internal rotation* are maintained during this maneuver. An assistant then seats himself on the stool at the end of the table and stabilizes the leg in the position (parallel to the table) in which the operator surrendered it to him for the rest of the operation.

Anteroposterior and lateral films are now taken. If they show an adequate reduction, anesthesia is begun and the operators scrub. If not, a Leadbetter reduction is carried out after induction of the anesthesia and the leg is then placed in the position previously described. Repeat films are now taken. If the patient has not been in Russell traction, the Leadbetter reduction is performed immediately.

The majority of nailings have been performed under cyclopropane anesthesia. It is believed that general anesthesia is preferable to spinal because of the possibility that the procedure may extend beyond the time limit of adequate anesthesia. Also, the pounding on the nail is usually very disturbing to the patient who is awake. A few of the nailings were done under local anesthesia in the very debilitated individuals with no displacement of the fracture, or with so little that it was considered wiser to sacrifice complete reduction rather than submit the patient to the risk of general anesthesia. There were no anesthetic deaths in this series.

The reduction is considered adequate if there is slight valgus over-reduction and no over-riding. These conditions being satisfied the operators scrub, prepare and drape a field which includes the area over the inguinal ligament. A Michel clip is then placed under sterile precautions halfway between the anterior superior iliac spine and the pubic tubercle and an anteroposterior film taken to be certain that it rests over the center of the femoral head. This film will be developed by the time the surgeon is ready to insert the guide wire in the direction of the clip.

The surgeon now makes his incision inferior to the bulk of the greater trochanter and progressing toward the knee over the shaft of the femur for a distance of about 2 inches. The incision should be deepened gradually rather than attempting to go down to bone on the first stroke as is so often done. If one is too hasty with the incision, it is often found not centered on the shaft and troublesome retracting and centering becomes necessary to expose the site of the wire and nail insertion.

The incision is carried down through the fascia lata, tensor fascia lata and the vastus lateralis muscles to the shaft of the femur. The periosteum is incised and elevated for a short distance at a point approximately  $1\frac{1}{2}$  inches below the notch at the inferior anterior edge of the greater trochanter. The cortex is punctured and a graduated guide wire is inserted with a hand drill directly toward the head of the femur, the location of which is indicated by the Michel clip. The appropriate deviation from the horizontal is determined by an estimate of the angle of declination made from the lateral film. The correct depth is estimated from the size of the individual and from the anteroposterior and lateral films with the graduated wire in position. In a large man the average distance to the articular surface of the head is 5 inches, in an average man  $4\frac{1}{2}$  inches and in an average woman 4 inches. Rarely is the distance only  $3\frac{1}{2}$  inches.

The guide wire then being inserted the

drill is disconnected and anteroposterior and lateral films are taken. If all has gone well, these will show the guide wire in a valgus position parallel to the calcar femorale in its lower third and centering the head in both views. There is no need for a readjustment if the wire is a small distance below the articular surface or, if it extends into the joint for a short distance, providing the alignment is correct since this deviation from the optimum can be corrected when the nail is driven in. The one exception is if the fracture is a subcapital one the wire must not be below its optimal position.

If the guide wire is found not to be in its correct position, it is far better to reinsert it correctly than to attempt to insert the nail in a corrected direction without the benefit of a guide wire. This seeming economy of time often leads to serious errors.

The guide wire being in an adequate position the proper length nail is chosen from the measurement on the graduated wire (from cortex of the femur to the articular surface). The nail is driven in over the wire with the aid of a hollow "head" which screws on the end of the nail proper. A check should be made every three strokes to be sure that the wire is not being driven into the pelvis. If it is, it should be extracted after the nail has been driven in only far enough to be firmly fixed in the bone. After this is accomplished the nail will not deviate appreciably from its correct course.

When the nail head is flush with the femoral shaft, the wire is withdrawn and the distal fragment is impacted into the proximal one with an instrument devised just for this purpose. It is hollowed out and has a curved distal end so that force may be applied around the nail site instead of on the head of it.

Anteroposterior and lateral films are taken with the nail *in situ*. Closure is begun while these films are being developed for if the operator has been careful the odds are excellent that the nail is in adequate

position. Furthermore, if a reinsertion is deemed necessary, it is only a matter of moments to reopen the incision. The muscle bellies are brought together with a few loose interrupted sutures of No. 00 plain catgut or fine silk, the fascia lata with closely spaced No. 0 chromic catgut or medium silk, the subcutaneous tissues with similar interrupted sutures of No. 000 plain catgut or fine silk and the skin is closed with interrupted vertical mattress sutures of fine silk. Adequate position is usually confirmed by the developed film at about this time.

The wound is then dressed and the previously placed Michel clip is removed. The leg is brought slowly onto the table and the ankles and feet are bound together to prevent external rotation of the nailed leg. The patient is returned to bed to recover from the anesthesia.

On the first postoperative day x-rays are obtained using the stationary machine in the x-ray department rather than the portable one on the ward. These films usually confirm the last films taken in the operating room. Under ideal circumstances the patient begins ambulation on the first postoperative day progressing to crutches without weight-bearing as soon as possible and is discharged as soon as the operative wound is healed. Frequently the patients are so debilitated that they are able to use crutches only after a considerable period of training and supportive treatment. Often it is difficult to put the point over that no weight-bearing should take place during the use of crutches. Some patients are kept in the hospital until there is evidence of callous because their discharge would jeopardize the result of the nailing. The patients are followed after discharge in the fracture clinic at one-month intervals or more frequently if indicated with check films at each visit. When clinical and x-ray union is apparently well established, light three-point weight-bearing is begun and gradually increased until the crutches are discarded, usually at six to nine months.

An attempt is made to follow these patients over a period of two years.

#### RESULTS

There were six Moore pinnings, one Moore-Blount nailing and one hundred twenty-one Smith-Petersen nailings performed.

*Moore Pinnings.* One man, eighty-one years old with a transcervical femoral fracture, suddenly became pulseless, incontinent, cyanotic and died on his 108th postoperative day. Autopsy was refused. At the time of his death he had abundant callus formation in moderate coxa varus deformity. One patient was bearing weight well with firm union, good position nine months postoperatively. He had had an intertrochanteric fracture. Another patient walked out without the aid of crutches two months postoperatively. Her injury had been a transcervical fracture. She had no pain and full motion at the time of her departure. She did not return to the fracture clinic. Three patients with two intertrochanteric fractures and one transcervical fracture did not return to the Fracture Clinic for follow-up. They were not bearing weight on discharge although the position of the fragments and callus formation was stated to have been good.

The Moore pins were removed in one of the patients not followed because they had entered the acetabulum and prevented motion. Motion was good following their removal on the seventy-third postoperative day.

*Moore-Blount Nailing.* The Moore-Blount nailing was performed upon a sixty-two year old man with an intertrochanteric fracture of the left femur. Four months postoperatively he had good callus formation and position and he was doing well with three-point weight-bearing. He did not return after that. This is a presumptively good result.

*Smith-Petersen Nailings.* Of the 121 patients 40 per cent were males and 60 per cent were females. The average age was

64.5 years. (Fig. 1.) The hospital mortality rate in 121 patients was ten, or 8.3 per cent, postoperatively; the average day out of bed for 120 patients (one not stated) was 5.28 days. (Fig. 2.) The average postoperative day out of the hospital for 111

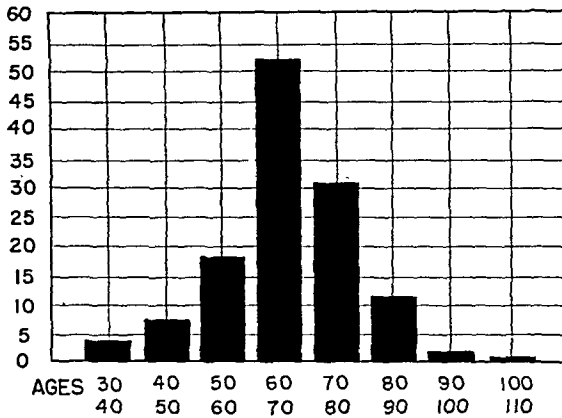


FIG. 1.

patients who left the hospital (ten deaths) was 49.7 days. The average postoperative time before full weight-bearing in the forty-nine patients who walked was 6.7 months. The follow-up percentage was 66 of 111 (ten deaths) or 59.5 per cent.

This follow-up percentage is a poor one relative to that obtained in many hospitals dealing with a different type of patient and with social service workers available to get patients back to follow-up clinics. This is by no means a criticism of the social service at Bellevue for the immediate sociologic problems presented by the average in- or out-patient are immeasurably greater than those encountered in most institutions.

It would be necessary to follow our sixty-six patients five years or longer to report adequately on the incidence of late aseptic necrosis of the head and/or neck, and the percentage of favorable results would doubtless be lower if our results were based on a five-year follow-up in every case.

**Smith-Petersen Nail Removals.** The nail was removed in 18 of 121 nailings performed (14.9 per cent), or in 27.3 per cent of the sixty-six patients followed-up. The reasons for removal were: (1) absorption of the head and/or neck, 6, (34 per cent); (2) loose nail, 5, (29 per cent); (3) absorp-

tion and loose nail, 4, (22 per cent); (4) inadequate position, removed immediately postoperatively, 1, (5 per cent); (5) removed at another hospital, 1, (5 per cent); (6) chronic suppuration localized in nail site, 1, (5 per cent).

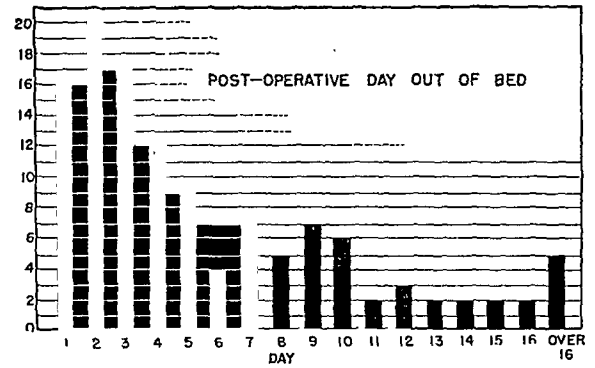


FIG. 2.

In the group of intertrochanteric fractures there were 16.7 per cent females and 83.3 per cent males, the average age was sixty-nine years, the average postoperative day out of bed was 8.5 days, the average postoperative day out of the hospital was 62.2 days and the average postoperative time without weight-bearing was 4.9 months. There were: 50 per cent good results; 33.3 per cent presumptively good results and 16.7 per cent fair results. In other words, 100 per cent walked in this group. There were no poor results and no secondary procedures were necessary.

Intertrochanteric fractures were routinely treated by Russell traction on the Second Surgical Division over this period. They were considered suitable candidates for Smith-Petersen nailing only if they had a sufficiently high intertrochanteric fracture without comminution so that the distal fragment provided enough bone for the nail to grip firmly. If this condition is satisfied, there must still be a good systemic or sociologic reason for early mobilization of the patient. If cases are selected in this fashion and the nail is placed in valgus position, the results in this small series seem to indicate that a Smith-Petersen nailing without a Hawley bar is an adequate method of fixation. (Table 1.)

A comparison (Table 11) between the

results in the general series and in the subcapital series indicates how much more guarded is the prognosis in the latter type of fracture.

All of the McMurray osteotomies performed in the series and one of the Whit-

fractures. Thus when one remembers that the subcapital results are included in the general series, the contrast is even more striking. The mid-transcervical fractures were not analyzed separately because nearly all previously reported series have

TABLE I  
SEPARATE ANALYSIS OF SUBCAPITAL FRACTURES

Case	Sex	Age	Post-operative Day Out of Bed	Post-operative Day Out of Hospital	Postoperative Time on Crutches	Nail Removed	Reason	Reconstructive Operation	Result
I	F	63	9	65	Never off crutches	Yes, 2 months postoperatively	Pain, absorption of the head and neck	McMurray osteotomy refused	On crutches 2½ years postoperatively Poor
II	F	57	8	20	One month against advice	No			No pain, full motion when last seen 1½ months postoperatively Presumptively good
III	F	59	4	35	9 months	No			No pain, slight limp, 50 per cent motion Fair
IV	F	76	13	31	Never off crutches	Yes, 3 months postoperatively	Loosening of the nail, absorption of the head and neck	McMurray osteotomy 2 years postoperatively	Hip fusion resulted; on crutches permanently Poor
V	F	58	3	20	4 months	No			No pain, good motion, function 1½ yr. postoperatively Good
VI	M	68	6	17	18 months	No			2 years postoperatively has pain requiring aid of crutches for any distance; has good motion Fair
VII	M	71	3	18	2½ months against advice	No			2½ years postoperatively has "very little pain, walks well" Good
VIII	F	72	5	117	Never off crutches	Yes, on 9th postoperative day	Nail was loose, placed in Russell's traction	Had marked absorption of the head but refused Whitman reconstruction	On crutches permanently Poor
IX	F	36	2	13	6 months	Yes, at Whitman reconstruction 16 months postoperatively	Patient had union, then absorption with great pain on walking	Whitman reconstruction 16 months postoperatively	5 months after the Whitman reconstruction she had little pain, good motion and was using a walking Thomas; will have a fair hip but it is a poor Smith-Petersen nailing result
X	F	70	2	17	Patient fell 1 month postoperatively, separated fragments	Yes, after fall	As indicated	McMurray osteotomy	Had excellent callus formation, good motion 4 months postosteotomy; using walking Thomas; might have been a good result Poor
XI	F	80	2	18	Never off crutches	No		Patient had absorption of head 5 months postoperatively	Secondary procedure not indicated for systemic reasons Poor

man reconstructions were done on patients with subcapital fractures. Six of the seventeen (35.3 per cent) poor results in the general series were in cases of subcapital

included their subcapital fractures in their results.

The Smith-Petersen nailing remains the treatment of choice in subcapital fractures

but it is important to realize a much more guarded prognosis is in order when nailing this type of fracture. The result is in all probability predetermined by the percentage of blood supply to the femoral head interrupted at the time of the fracture.

TABLE II

	Subcapital Fractures (per cent)	General Series (per cent)
Good or presumptively good results.....	27.3	62.1
Fair results.....	18.2	12.1
Poor results.....	54.5	25.8

This will depend on the relative amount of blood supplied through the round ligament and on whether or not the vessels in the capsular reflection are completely torn.

We have had no experience with the additions (such as bone pegging) to the Smith-Petersen nailing which are designed to improve the blood supply to the head so we cannot report on their efficacy. The experience with subcapital fractures indicates that such measures are justified even if they lower the incidence of aseptic necrosis only a little.

## SUMMARY

1. The historical development of internal fixation of fractures through the femoral neck and trochanters is reviewed.
2. The anatomy of the femoral head, neck and trochanters pertinent to internal fixation is discussed.
3. A successful technic for the Smith-Petersen nailing is described.
4. The handling within the hospital of 128 patients with internal fixation by Smith-Petersen nailing, Moore pins and the Moore-Blount nail is reported. Results in the sixty-eight patients followed-up after discharge are discussed. These are reported in three categories determined by the method of internal fixation employed, and the results in Smith-Petersen nailing

August, 1949

of intertrochanteric and subcapital fractures are also analyzed separately.

Recommendations are made concerning the choice of patients for the various methods of treatment. The Smith-Petersen nailing is thought to be the preferable method in the vast majority of instances. A non-comminuted high intertrochanteric fracture is stated to be suitable for Smith-Petersen nailing without the addition of a Hawley bar. The Moore-Blount nail is desirable in low intertrochanteric fractures.

The results for the entire series (all categories) of 128 cases were: (1) average age, 64.7 years; (2) hospital mortality, 8.6 per cent; (3) average day out of bed, 5.4 days; (4) average day out of hospital, 50.4 days; (5) follow-up percentage: 68 of 117 (excluding deaths), 58 per cent. The results for all categories on those patients followed-up are: good or presumptively good, 63.2 per cent; fair, 11.7 per cent; poor, 25.1 per cent.

Because a fair result is defined as one in which the patient walks with union but with sufficient pain to restrict activity and/or a noticeable limp, 74.9 per cent of those operated upon subsequently walked without aid. A greater number eventually walked following secondary procedures, but this percentage represents the prognosis for ambulation after primary internal fixation.

These results were obtained on a general surgical service over a ten-year period. The surgeon was a member of the house staff in the great majority of instances. We believe that the results give an accurate estimate of what can be expected of the procedure in the hands of a careful general surgeon thoroughly familiar with the technic.

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ONE of the most common causes of hip disability in adolescent boys is separation of the capital femoral epiphysis. Predisposing factors are variable, including possible endocrine and chemical imbalances as well as unusual anatomic changes of the hip joint at this age. The immediate cause of the slipping, of course, is almost invariably some form of direct or indirect trauma to the joint. Unless recognized and correctly diagnosed, a partial disability with permanent limping may remain. If one wishes to obtain the best results possible, x-rays should be taken of both hips to show clearly the abnormality present; treatment must be promptly instituted and adequately continued until such time as firm bony union occurs between the head and neck of the femur. (Richard A. Leonardo, M.D.)

# MALIGNANT TUMORS OF THE THYROID GLAND

## DIAGNOSIS, MANAGEMENT AND END RESULTS

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THYROID carcinoma arises most frequently in nodular goiter. All nodules of the thyroid gland should be removed, be they single or multiple, large or small, *before* they begin to give rise to symptoms either locally by increasing in size or systemically because of toxicity.

The small solitary adenoma can be more serious than the large colloid goiter. The size of the nodular goiter is no index as to the degree of toxicity or the presence or absence of malignancy. It is the small, discrete nodule which usually gives rise to carcinoma.

With our improved surgical technic and a practically nil mortality rate, more lives can be saved by taking a more radical attitude toward nodular goiter.

### INCIDENCE

Robertson Ward<sup>1</sup> in 1944 reported an incidence of 4.8 per cent malignant tumors arising in nodular goiter; Cole, Slaughter and Rossitier<sup>2</sup> in 1945 reported an incidence of 7.2 per cent cancer in nodular goiter. Hinton and Lord<sup>3</sup> recently found the incidence of carcinoma to be 7.6 per cent in clinically benign nodular goiter as compared to an incidence of 6.7 per cent carcinoma in clinically benign breast tumors.

Early removal of all nodular goiters should be a must in the treatment or consideration of carcinoma of the thyroid because prevention is the first step in the treatment of carcinoma. The prognosis in the clinically benign yet histologically positive malignant goiter is much better than in the clinically malignant goiter. Isolated nodules or true adenomas in contradistinction to nodules of endemic goiter (colloid goiter) are ten times likelier to be malignant than any other type of enlargement.

Schlesinger, Cargill and Saxe<sup>4</sup> in 1938 reported that 8.2 per cent of all thyroids examined at autopsy contained distinct nodules more than 1 cm. in diameter; in nodular goiters from 112 patients they found five carcinomas (4.5 per cent) and one sarcoma.

In this series of 1,500 consecutive thyroidectomies 668 patients were operated upon for nodular goiter and of these thirty-four were malignant, i.e., an incidence of about 5 per cent. The average age of this group was forty years. The youngest patient was fifteen years of age and the oldest, seventy-seven. There were eight males and twenty-six females, an incidence of one male and three females. Presence of goiter varied from three months to twenty years before surgery was undertaken. There were no operative mortalities.

### SIGNS AND SYMPTOMS OF THYROID MALIGNANCY

The clinical symptomatology and physical signs in malignancy of the thyroid gland depend upon the stage of the disease at the time of examination.

Warren<sup>5</sup> classifies malignant tumors in three groups histologically, low grade malignancy, moderate degree of malignancy and high degree of malignancy. In the first group are malignant adenoma, papillary cyst adenoma, papillary adenocarcinoma, aberrant goiter and Hürthle cell carcinoma; in the second group, moderate degree of malignancy, is adenocarcinoma; in group III are small cell carcinoma and giant cell carcinoma.

In Group I the history is usually one to five years' duration; occasionally there is a sudden, rapid increase in size. In this group the early cases of malignancy are diagnosed

as only simple adenoma unless the history is of long duration.

In the cases of Group II and Group III there is usually no doubt as to malignancy. There is rapid increase in size accompanied by dilated superficial cervical veins and a firm, fixed infiltrating mass in the region of the thyroid gland. Stridor may or may not be present depending upon the degree of compression of the trachea. Hoarseness may be present in advanced cases indicating involvement of the recurrent laryngeal nerve.

In one patient in our series, a forty-four year old female, hoarseness was the only symptom present. This was of three months' duration. Examination of the thyroid gland revealed no palpable mass; x-ray of chest was negative for aneurysm, intrathoracic goiter or other masses. Laryngoscopy revealed a left vocal cord paresis. Exploration of the neck was advised for a tentative diagnosis of carcinoma of the thyroid involving the left recurrent laryngeal nerve. At operation a small, discrete adenoma approximately 1 cm. in diameter was found on the posterior medial aspect of the left thyroid lobe at the lower pole encroaching upon the left recurrent laryngeal nerve. A left total hemithyroidectomy was performed removing the left lobe and isthmus and the nerve was freed. Pathologic examination revealed an adenocarcinoma. The patient is alive and well today.

There are two common causes for change in consistency and increase in size in a thyroid adenoma: A, hemorrhage into the adenoma and B, malignant degeneration. Hemorrhage is always accompanied by a sudden increase in size, sudden pain and localized tenderness.

Malignancy usually occurs without pain or tenderness and is less sudden in its enlargement. A non-inflammatory reaction about a thyroid adenoma into which hemorrhage has taken place may produce some degree of fixation but this is far less definite than the fixation caused by malignant degeneration. At operation when the prethyroid muscles are found adherent

to the thyroid gland one should suspect malignancy. Malignant changes may take place at any age and in any sized adenoma. Malignant degeneration of an adenoma of the thyroid which has existed for a long time can be recognized by a change in consistency from one of moderate firmness to that of induration. Malignant disease of the thyroid gland is rare in toxic adenoma and in diffuse toxic goiter. In this series we encountered carcinoma in one of each type.

Malignancy must be differentiated from chronic thyroiditis which generally follows some painful enlargement of the thyroid gland secondary to a recent upper respiratory infection. When the thyroiditis becomes chronic, there is a stony hard symmetrical enlargement of both lobes of the thyroid gland. In malignancy there is a firm, asymmetrical enlargement of the thyroid gland and the contour of the gland is lost.

Lateral, aberrant thyroid nodules arise from the ultimo branchial body as a result of abnormal embryologic development and are subject to varying degrees of enlargement. The diagnosis of aberrant thyroid is not too difficult. The tumor may be single or multiple; it is a symptomless swelling of the neck which gradually increases in size over a period of months or years. The mass is movable and is located in the neck in front of the sternomastoid beside the internal jugular vein. All of these tumors must be considered actually or potentially malignant and many show definite cancer.<sup>6</sup> They have a characteristic gross appearance and on section show papillary cyst-adenoma or papillary adenocarcinoma with little differentiated adult thyroid tissue.

Radical neck dissection is advocated by the Lahey Clinic followed by deep x-ray radiation therapy. The lesion is usually of low malignancy and is radiosensitive.

We encountered one case in our series. This occurred in a thirty year old female giving a history of a symptomless mass in the right side of her neck of six months' duration slowly increasing in size. The diagnosis of malignant aberrant thyroid

was made preoperatively, primarily because of a familial history of malignant goiter. Her seventeen year old brother had been operated upon by me for a malignant goiter six years prior to her operation. The right lobe and isthmus and two aberrant

TABLE 1

	No. of Cases	Per cent
Group I—Low grade malignancy		
Malignant adenoma.....	5	16
Papillary carcinoma.....	10	30
Aberrant goiter.....	1	3
Hürthle cell carcinoma.....	0	0
Group II—Moderate degree malignancy		
Adenocarcinoma.....	15	45
Group III—High degree carcinoma		
Small cell carcinoma.....	1	3
Giant cell carcinoma (squamous)....	1	3

thyroid masses were removed during a total hemithyroidectomy. Microscopic section revealed papillary carcinoma of the aberrant thyroid but absence of carcinoma in the homologous removed thyroid lobe.

The use of x-ray in the diagnosis of carcinoma of thyroid is limited and is of value only if metastases are present.

#### MANAGEMENT OF MALIGNANT GOITER

Treatment consists of the removal of the premalignant lesion, the benign thyroid adenoma. Active treatment of malignant thyroid tumor consists of surgical operation followed by radiation therapy.

In all cases of benign nodular goiter a subtotal hemithyroidectomy and removal of the isthmus is performed. If bilateral lesions are present, a subtotal thyroidectomy is carried out. I believe that if thyroidectomy is not performed and only the discrete nodule or adenoma is removed, the possibility of recurrence is great for oftentimes there may be a small adenoma in the paranodular thyroid tissue which can be discovered only on microscopic section.

If the diagnosis of malignancy is made at the time of operation, e.g., if invasion of the capsule of the thyroid gland is present or malignant change is found within

the adenoma, a total hemithyroidectomy with removal of the isthmus is performed. All cases are followed up with postoperative radiation therapy.

In advanced cases of carcinoma total thyroidectomy should be attempted or as much malignant tissue removed as possible. A prophylactic tracheotomy should accompany this procedure and the tube kept in place for several weeks after radiation therapy has been completed.

It had been hoped that with the use of radioactive iodine, metastatic carcinoma of the thyroid would be greatly benefited. Up to the present time the results are not too encouraging. One patient in this series, who after six years of survival developed metastatic carcinoma of the lung, was treated with radioactive iodine to no avail. She died shortly afterward. Another patient is now receiving radioactive iodine treatment for metastasis three and one-half years after her original thyroidectomy. Best results are obtained in those lesions which are actively secretory and, unfortunately, these are few.

#### END RESULTS

In a series of 1,500 consecutive goiter operations thirty-four cases of malignancy of the thyroid gland were encountered in 668 cases of nodular goiter, giving rise to an incidence of about 5 per cent of carcinoma in nodular goiter. This coincides with the incidence of malignant goiter found in other clinics. Of the thirty-four patients, twenty-eight are alive. All received postoperative radiation therapy. Of the 28 living patients one is suffering from lymphatic leukemia which developed three years postoperatively; one patient is presently receiving radioactive iodine for local recurrence four years postoperatively; twenty-six patients are living and well; six patients in Group II and Group III died postoperatively, one from coronary disease four years after operation and five from metastatic carcinoma seven, six and four years, and seven and three months, respectively.

Of the patients who died it is interesting to note the lesions were quite advanced. The oldest survival period in this series is fourteen years.

#### SUMMARY

1. Malignancy of the thyroid gland was found in approximately 5 per cent of all cases of nodular goiters. This incidence can best be reduced by advising early removal of all thyroid adenomas.

2. Whenever possible, advanced extensive malignant thyroid tumors should be removed by radical operation combined with tracheotomy.

3. Radiation therapy is advocated in all cases postoperatively.

4. Malignant thyroid disease is curable depending upon the histologic type of the disease.

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ON seeing patients with familial multiple polyposis of the colon we are not surprised to learn that occasionally one of them has two or more primary cancers, each developing in a separate polyp. However, multiple primary cancers of different organs are rare. Recently such a case was reported (D. M. Spain) in which separate and totally unrelated primary cancers were found in the bronchus, the prostate gland and the pancreas. (Richard A. Leonardo, M.D.)

# LOW BACK PAIN AND SCIATICA\*

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THE syndrome of low back pain, with or without sciatica, continues to constitute a significant threat to the equanimity of the orthopedic and general surgeon alike. This is particularly true when one's practice includes industrial beneficiaries. A review of the literature represents a wealth of varying theories as to the etiology of the syndrome and its treatment, and one readily appreciates the popularity of each during its heyday. With careful consideration, however, it appears that all of these theories are based upon various manifestations and accompanying pathologic changes and none strike at the underlying basis of the disorder, except that of Dr. Paul C. Williams.<sup>1-4</sup> The purpose of this paper is to present the results obtained in the treatment of 150 patients with low back pain by the Williams flexion technic. To evaluate the method properly we believed we were justified in treating all patients with low back pain, with or without sciatica, in the same way since if Williams' theories are correct: (1) The fundamental basis for the syndrome is the same even though other factors such as spondylolisthesis, congenital anomalies about the lumbosacral joint, herniated nucleus pulposus, contracted lateral fascia, hypertrophied piriformis muscle, etc., were present, and (2) even though extravertebral disease may produce this symptom complex, the underlying changes in the back as a result of the extravertebral disorder must be the same as in those cases resulting from primary changes in the lumbosacral joint (that is, degeneration of the lumbosacral disc). At first thought such a conclusion appears ridiculous but clinically the syndrome was not observed in this clinic without demonstrable changes

fulfilling the requirements laid down by Williams. (Figs. 1 and 2.)

On admission to the clinic all patients were hospitalized, principally to permit rigid control but also because most of our patients were transients or lived out of town. A complete history was obtained with especial reference to the exact method of injury and sequence of events following injury. Complete physical examination and routine urine and blood studies were done and daily back examinations made in detail as this was the only method by which signs and symptoms as well as progress of treatment could be evaluated. X-ray examination included lateral, anteroposterior and oblique views of the lumbar spine and pelvis (using the Williams technic)<sup>5</sup>; this was performed in all cases. As the treatment progressed the films were repeated to determine the success of flexion treatment on overcoming the hyperextension of the lumbosacral joint. In all cases of neurologic changes involving the lower extremities, pantopaque studies were made. (Tables 1 to v.)

On admission all patients were placed on complete bed rest in a flexed position (Fowler's). The two exercises aimed at development of the abdominal and gluteal muscles were started immediately under the supervision of the ward therapist who devoted full time to these patients. When sciatica was present, intermittent traction was instituted without sacrificing flexion. A bivalved padded plaster cast incorporating a wire loop was used for this purpose. This method was non-irritating and allowed adequate examination of the extremity. As soon as the acute symptoms subsided stretch exercise for the sacrospinalis and bed stretch exercises for the

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FIG. 1. Normal lumbosacral disc, taken by Williams technic. There is no narrowing present and no break in the Hadley S curve indicating no subluxation at facets (retouched).

hip flexors were initiated, taking care in the latter not to lose flexion in the lumbosacral joint. Heat in the form of infra-red with massage was used liberally for relief of muscle spasm in the acute cases. This also was administered on the ward. When localized tenderness was present in the lumbar area, local procaine was used to break up pain arcs that tended to become fixed. The patients' backs were not taped; no support was applied in this stage of the treatment. It should be emphasized that patients with chronic cases as well as those with acute cases were placed under this same regimen. This was particularly important in those with compensation cases as the rigid regimen seemed to overcome suspicion and prejudice which had been created in these patients by previous failures in treatment. We readily agree that most chronic low back syndromes, compensation and otherwise, have a large functional overlay. We believe, however, this is



FIG. 2. Normal lumbosacral disc, taken by Williams technic. The disc is not narrowed and foramina remains large without encroachment of the superior articular process of the first sacral element.

usually the result of unsuccessful treatment in the past and that low back pain is rarely a manifestation of a psychoneurosis. Therefore, to accomplish anything in these cases rapport must be re-established and can best be accomplished by thorough examination and re-examination combined with an energetic treatment regimen that leads to relief of the primary condition.

Those patients who were completely relieved by the aforementioned routine were allowed out of bed after they had been pain-free for two to three days. Most patients with acute cases fell into this group, the average duration of symptoms being five to seven days. During this time they had been thoroughly indoctrinated in flexion principles and activity was gradually increased. The ambulatory hip flexor stretch exercise devised by Williams was then added to their flexion exercise routine,

and the patient's ability to maintain a flat lumbar curve was observed. When a large abdomen was present, a Kerr type belt was applied to assist recovery of the abdominal muscle tone and remove the weight from the lumbosacral joint. It is well to

For all longshoremen or men whose occupation requires lifting a modified Kerr belt is prescribed. That a tight abdominal binder protects the back in lifting is general knowledge among most labor groups. (Table VI and VII.)

TABLE I  
(GENERAL)

No. cases, 150	
Age spread, 16 to 62	
Average duration symptoms prior to admission.....	23 days
History of previous attacks.....	27%
History of trauma.....	100%
lifting.....	88%
other.....	12%
Initial treatment elsewhere.....	92%
with improvement.....	16%
without improvement.....	84%
Average duration of hospitalization.....	17 days

TABLE II  
PRESENTING SYMPTOMS

	No. Cases	Per Cent
Pain in back alone.....	33	22
Pain in leg alone.....	8	5
Pain in back and one leg.....	108	72
Pain in back and both legs.....	1	0.67
Numbness in leg or foot.....	42	28
Weakness in leg or foot.....	10	6.7
Sphincter disturbance.....	0	0

TABLE III  
PRESENTING SIGNS

	No. Cases	Per Cent
Scoliosis.....	92	61.3
Lumbar muscle spasm.....	135	90
Positive Lasague's sign.....	118	78.6
Positive Patrick's sign.....	18	12
Positive Ely's sign.....	145	96.6
Positive Ober's sign.....	38	25
Contracted hip flexors.....	124	83.6
Positive Naffziger's sign.....	53	35.3
Positive Soto-Hall test.....	75	50
Absent knee jerk.....	0	0
Absent ankle jerk.....	41	27.3
Hypesthesia L 5, S 1.....	45	30
Muscle weakness, lower leg.....	16	10.6
Positive Williams flexion test.....	128	85.3

insist upon weight reduction in obese patients. A recurrence of pain upon ambulation places the patient into the next group to be discussed. Freedom of recurrence depends upon the patients' cooperation in maintaining the abdominal and gluteal development and observing the principles of flexion in sitting, riding and working.

TABLE IV  
PANTOPAQUE MYELOGRAPHY

	No. Cases	Per Cent
No. performed.....	68	45.3
No. positive.....	62	41.3
Defect L 4.....	16	10.6
" L 5.....	43	28
" L 4 and L 5.....	3	2

TABLE V  
X-RAY FINDINGS

	No. Cases	Per Cent
Degeneration lumbosacral disc.....	122	81.3
Hyperextension lumbosacral joint.....	96	64
Hypertrophic arthritic changes.....	64	42.5
Congenital anomalies lumbosacral joint..	24	16
Spondylolisthesis.....	3	2

TABLE VI  
OPERATIONS

	No. Cases	Per Cent
Ober fasciotomies.....	12	8
Soutter stripping.....	3	2
Excision herniated nucleus pulposus.....	24	16
Fusion lumbosacral region.....	6	4
Tenotomy piriformis.....	1	0.67
Facetectomy.....	1	0.67

TABLE VII  
SUPPORTS FITTED

	No. Cases	Per Cent
Total.....	57	38
Kerr belts.....	18	12
Williams brace.....	4	2.6
McAusland brace.....	35	23.3

When there is no response to the aforementioned treatment routine or recurrence of symptoms on ambulation, a Williams flexion cast is applied and the exercise regimen intensified. Casts must be correctly applied with special attention to bring the postero-inferior aspect well down on the sacrum and forcibly scaphoid the abdomen. The patient is kept in the cast two weeks after all symptoms are relieved. The cast is then replaced by a brace. The Williams brace is ideal but difficult to construct. A modified McAusland lumbosacral





FIG. 3



FIG. 4



FIG. 5

FIG. 3. With degeneration lumbosacral disc, the fifth lumbar vertebra settles on the sacrum, and with the subluxation of the facets there is encroachment upon the foramina by the superior articular process of the first sacral element and posterior migration of the fifth lumbar body. This latter is considered a true deformity by Williams and an optical illusion by Willis (retouched).

FIG. 4. The degeneration of the disc is often unilateral at first as illustrated here. Note the narrowing on the right with subluxation of the facet and break in the Hadley S curve (retouched).

FIG. 5. As degeneration of the disc proceeds, settling continues until the bodies come into contact or until the superior articular process of the first sacral element reaches the roof of the foramina. Note the marked narrowing of the foramina in this case (retouched).

support is suitable and cheaper. The lumbar stays are lengthened to reach the third sacral element and the abdominal pad increased in size. This permits adequate flexion, and the patient is uncomfortable unless he tilts his pelvis thus correcting the hyperextension of the lumbosacral joint.

The patient who gains relief with this regimen remains relieved as long as he maintains his abdominal and gluteal muscle development and observes flexion throughout the day and night. He learns to foretell an acute exacerbation when he finds he can no longer flatten his lumbar curve. This test provides the patient with a measure of the success of his pelvic tilting exercises. Maintaining the lumbosacral joint in flexion soon becomes instinctive in all activity.

In long-standing hyperextension syndromes with contracture of the hip flexors,

stretching exercises usually are not successful; in order to tilt the pelvis a Soutter stripping<sup>6</sup> and Ober's fasciotomy<sup>7</sup> are necessary. It is well to remember that the hamstring muscles are not contracted but, instead, are overstretched. The universal practice of the physiotherapist to stretch this group of muscles by forced straight leg raising should be discouraged as this procedure not only fails to tilt the pelvis but results in severe pain, increased muscle spasm with increased hyperextension and exacerbation of the sciatica.

The older age group who are relieved of the low back pain by this regimen rarely show any x-ray change in the lumbosacral relationship and often show little change in posture. The basis for their relief symptomatically must be on the subsidence of effusion and edema about the facets with a resultant increase in foramina size. Con-

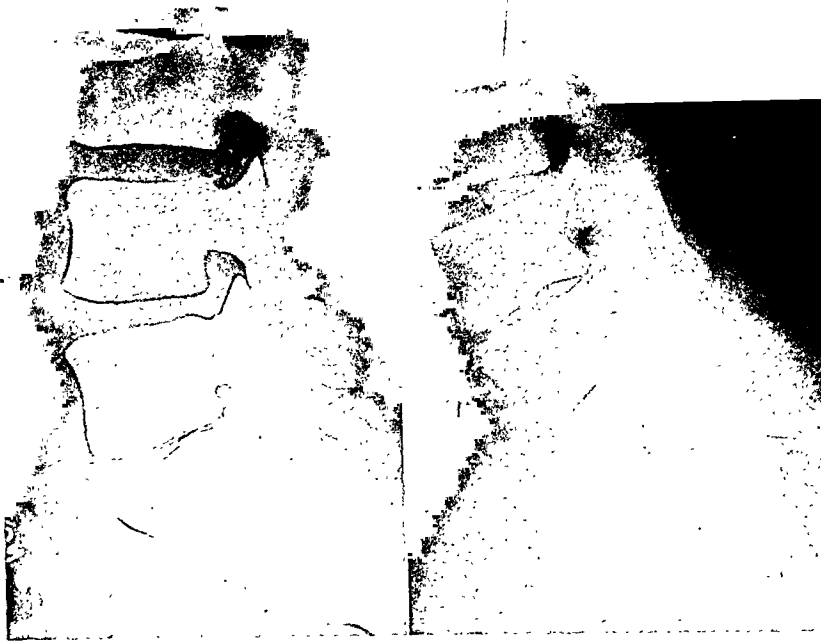


FIG. 6

FIG. 7

FIG. 6. When the superior articular process of the first sacral element is short, the bodies of the fifth lumbar and sacrum are allowed to come into contact and a shallow cavity may develop in the superior articular surface of the first sacral vertebra by the posterior inferior edge of the fifth lumbar vertebra. Due to hyperextension the anterior portion of the disc is spared (retouched).

FIG. 7. Degeneration of the fourth and fifth lumbar disc with herniation treated by excision of disc and posterior spinal fusion. Pain persisted until facetectomy was performed (retouched).

sequently, this class is particularly prone to recurrences and are restricted as to the type of work to which they may return. They can, however, continue a useful life if assisted by a brace, weight reduction and abdominal and gluteal muscle exercises. Fixation gradually becomes complete and the patient obtains permanent relief. Fusion of the lumbosacral joint is contraindicated in the older age group as the joint above the arthrodesis will not tolerate increased stress without symptoms. If relief can be obtained by conservative measures, it appears best to accept a partial disability in the older age group than to subject the patient to an operative procedure that has such a large failure rate. (Figs. 3, 4, and 5.)

The next group of patients to be considered are those suffering from low back pain with sciatica, when patients have been subjected to our treatment regimen and have failed to respond favorably. Fortunately, this group is small and may be considered as follows: (1.) Those patients

with typical findings of degeneration of the disc with settling of the lumbosacral joint and negative pantopaque myelography. This class is usually made up of the older age group in which the hyperextension of the above joint is fixed and when hypertrophic changes about the facets are present. Here the foramina are so encroached upon that there is actual bony pressure on the root. The only solution appears to be fusion with a facetectomy. Failure to include the latter procedure usually produces little or no relief for the patient.<sup>8</sup> At operation it will be found that the lumbosacral joint is so fixed in hyperextension that it cannot be flexed but that some motion persists thus accounting for the constant nerve root irritation. (2.) Those cases in which a herniated nucleus pulposus exists and has failed to reduce with adequate conservative treatment or when sufficient nerve root pressure is present to produce muscle weakness or paralysis. In these cases the sciatica often overshadows any back pain

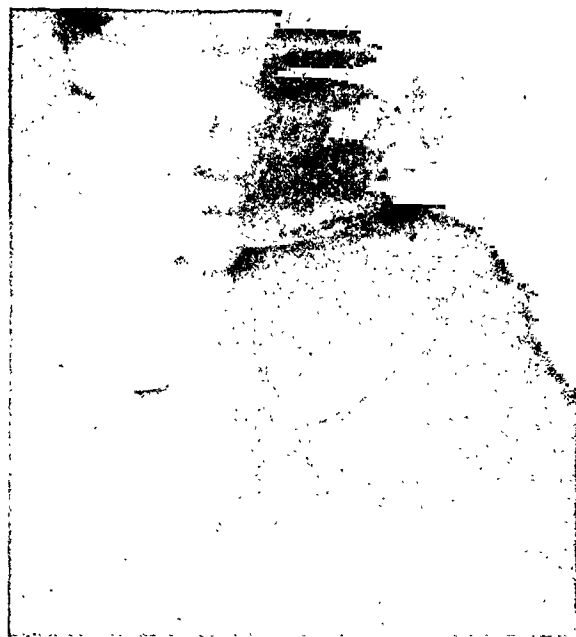


FIG. 8. Lumbosacral joint found on barium enema studies. This man was sixty-eight years old and had no pain or disability referable to his low back. He had, however, suffered with recurrent low back pain and sciatica up until the last ten years when natural fixation apparently occurred. Note calcification of the anterior longitudinal ligament. Although foramina is small, the superior articular process of the first sacral element is small which explains absence of continued nerve root pressure (retouched).

present or the latter may be entirely absent. Surgery is indicated, and immediate postoperative results are uniformly good, with the patient gaining complete relief from pain and exhibiting a quick return of full motion of the back. What should be emphasized, however, is that herniation of the nucleus pulposus is merely an incident in the underlying basic disorder, and surgical removal is just an expedient and not a complete treatment of the entire pathologic lesion. It is extremely important to treat these patients postoperatively by the same energetic flexion technic as one would a degeneration of the disc without herniation. The process is progressive and this accounts for the poor results seen in series which have been adequately followed. It appears that fusion of the lumbosacral joint following excision of the disc is not the solution as the fourth lumbar disc then becomes the pivot and subjected to all the stress and strain to which the fifth suc-

cumbed. It seems reasonable to believe postoperative discs can be protected from hyperextension disease by the Williams flexion technic in the same way that patients with degeneration of the disc re-

TABLE VIII  
RESULTS

	No. Cases	Per Cent
Recovered, asymptomatic and restored to full duty.....	92	61.3
Improved, asymptomatic but activity limited.....	32	21.3
Unimproved by treatment regimen.....	26	17.3
Incidence of recurrence in group followed eighteen months.....	..	14

TABLE IX  
RESULTS IN CASES OF HERNIATED NUCLEUS PULPOSUS

	No. Cases	Per Cent
Cases treated conservatively.....	38	61.3
Full recovery.....	36	94.7%
Improved but with residual hypesthesia or weakness.....	2	5.3%
Unimproved.....	0	0%
Cases treated by simple excision herniated nucleus pulposus.....	21	33.8
Full recovery.....	19	90.5%
Improved but with residual hypesthesia or weakness.....	2	9.5%
Cases treated by excision nucleus pulposus and fusion.....	3	4.8
Recovered.....	0	0%
Improved but with residual back discomfort.....	2	66.6%
Unimproved.....	1	33.3%
(Later improved by facetectomy)		
Total.....	62	

spond. (Figs. 6, 7 and 8.) (Tables VIII and IX.)

A word should be said about that group of patients who exhibit all the previously described changes with degeneration of the lumbosacral disc, that is, settling of the lumbosacral joint, hyperextension with subluxation of the facets, encroachment of the superior articular process of the first sacral element upon the foramina and associated arthritic changes and yet who are asymptomatic. Careful examination of these patients will exhibit two findings that account for their freedom of symptoms. The foramina will be found to be unusually large, and lateral films taken in flexion and extension will show the lumbo-

sacral joint to be fixed with no detectable motion. These patients are almost unvariably of the older age group and they usually give a history of back discomfort and disability recurrently while young that gradually subsided with old age when natural fixation occurred.

#### SUMMARY

An attempt has been made to evaluate use of the Williams flexion technic in treatment of 150 compensation patients suffering from low back pain and sciatica. Relief of symptoms and rehabilitation have been uniformly good, and this technic seems to offer an adequate solution of a difficult problem in industrial surgery. It is suggested that the poor late results in the over-all treatment of herniated nucleus pulposus might be bettered by a rigid flexion regimen postoperatively.

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# THIOURACIL AND SURGERY OF THE THYROID GLAND

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IT seems appropriate to review at this time one hundred cases which have been prepared for surgery using thiouracil either alone or in combination with iodine for varying lengths of time before operation. Of these, eighty-one were new cases of primary hyperthyroidism and nine were recurrent cases. Thirty-three patients were operated upon without the use of iodine in the preparation; the majority of these were operated upon in the early days of thiouracil preparation, in the latter part of 1943, and the early part of 1944. Sixty-seven patients were prepared with thiouracil and iodine in different combinations. A few of these patients were prepared by other doctors under our specific instructions, but the great majority were either under the care of Doctor R. H. Williams or under our own personal care.

Early in the course of our experience with thiouracil prepared patients it became apparent that the technical difficulty of actual surgery was greatly increased as compared with iodine prepared cases. This increased technical difficulty arose on the basis of three separate factors (1) An increased vascularity in which all the tissues of the neck appeared to participate; (2) increased friability of the gland and of the overlying pretracheal muscles and (3) marked adherence of all structures, with partial obliteration of normal cleavage planes.

The increase in vascularity of the tissues became evident as soon as the skin incision was made and the skin flap elevated. Persistent bleeding from myriads of minute vessels prolonged this phase of the operation and necessitated tedious clamping and tying of large numbers of small vessels. In addition to the undesirable prolongation of the operation, the necessary use of large

amounts of ligature material resulted in an increased incidence of serum accumulation beneath the skin-flap during the early post-operative period, and in the necessity of employing drainage much more frequently than we had been accustomed to in iodine-prepared patients.

The increased vascularity was much more troublesome in relation to the thyroid gland itself. This frequently presented as a diffuse veil-like web of fine, interlacing thin-walled friable vessels of capillary size and, somewhat larger, spreading over the entire surface of the lobe and dipping down over its lateral margin toward the carotid sheath. The slightest manipulation of the gland and even light sponging often resulted in a diffuse ooze from a broad surface which was most difficult to control. Particular difficulty was encountered in elevating the lateral lobe and retracting it medially. The vessels in this area were larger than usual and extremely thin-walled, and presented such a dense network that even the most painstaking and careful dissection produced a diffuse oozing of blood obscuring the field and greatly hampering this stage of the procedure.

The safe execution of this stage of the operation requires a clear, dry field in which the anatomy of the area can be clearly visualized. The increased danger of damage to the recurrent laryngeal nerve or the parathyroid glands which must inevitably result from operating in the face of bleeding so difficult to control constituted, we believed, the most serious objection to the use of thiouracil in the preparation of these patients for operation.

Further difficulty was encountered as a result of the abnormal adherence of the pretracheal muscles to the underlying gland. In many cases this attachment was

so firm that in elevating the muscles from the gland, thin strips of friable muscle remained plastered to the thyroid capsule, and the maneuver almost invariably produced profuse bleeding from the network of vessels covering its surface. The friability of the muscle and particularly of the thyroid gland itself led to annoying and troublesome difficulties. Simple lifting of the edge of the thyroid muscle with toothed forceps preliminary to separating it from the thyroid gland often resulted in tearing of the friable muscle. The gland itself was in most cases greatly altered in consistence as a result of the thiouracil-induced hyperplasia. In some cases the gland was soft and mushy and in others the consistency was comparable to that of Roquefort cheese. The capsule of the gland appeared to participate in these changes, and its tensile strength was diminished to the point that the double hooks employed to elevate and rotate the gland medially frequently tore out, causing additional troublesome bleeding. Hemostats frequently cut through and fell off causing further bleeding. Ligatures likewise frequently cut through the soft friable glandular tissue. For the same reasons suture of the gland remnants presented difficulty because of the cutting through of the approximating stitches.

Despite the greatly increased technical difficulties experienced in dealing with these cases, the advantages of thiouracil preparation were so striking in other respects, at least in certain types of cases, that it seemed most desirable to retain these advantages if the undesirable local effects could be modified.

These effects seemed without much question to be a component part of the thiouracil-induced hyperplasia of the thyroid gland. Modification of these effects was attempted by bringing about some measure of involution of the gland by the administration of iodine in the form of either potassium iodide or Lugol's solution during the latter phase of the preparation. This was necessarily begun at first on a trial and error basis, and there has been

considerable variation in the time and duration of the iodine administration as well as variation in the duration of thiouracil administration and in the amount given. We have attempted to analyze the results with respect to the effectiveness of iodine administration in modifying the local effects of thiouracil which affect the technical performance of the operation.

We have listed three major causes contributing to increased technical difficulties during surgery. The frequency with which these occur after the various methods of preparation is noted in the summary.

#### SUMMARY OF ONE HUNDRED CASES AND THEIR PREPARATION FOR SURGERY

1. Thirty-three cases were prepared with thiouracil alone, the duration of treatment varying from less than two weeks to over six weeks. Excessive bleeding occurred in twenty-one cases, excessive friability of the gland in two cases and abnormal adherence of muscles in three cases.

2. Four cases were prepared with thiouracil for from four to twenty weeks with iodine added during the last week. Excessive bleeding occurred in two cases.

3. Eleven cases were prepared with thiouracil for from two to over six weeks and iodine added during the last two weeks of preparation. There was excessive bleeding in ten, the gland was friable in five and the muscles adherent in six cases.

4. Fourteen patients were prepared with thiouracil for from two to over six weeks and iodine was added for the last two to four weeks. There was excessive bleeding in nine, the gland was friable in five and the muscles adherent in four.

5. Four patients were prepared with thiouracil for from eight to twelve weeks and iodine added for the last six to eight weeks. There was excessive bleeding in four, the gland was friable in one and the muscles adherent in two.

6. Ten patients were prepared with iodine but thiouracil had in addition been given within two weeks to one year. These may be classed as thiouracil failures due to

the development of toxic reactions. There was excessive bleeding in six, the gland was friable in one and the muscles adherent in three patients.

7. Seven patients had had iodine for several months to years and then had received thiouracil for from one to fourteen weeks. There was excessive bleeding in four, the gland was friable in one and the muscles adherent in 1 patient.

8. Seventeen patients were prepared with many different combinations of thiouracil and iodine not susceptible to the above classification.

#### CONCLUSIONS

1. Considerable technical difficulty has been experienced during the course of operation on thyroid glands prepared for surgery by thiouracil with or without iodine in combination.

2. Even after considerable experimentation with various types of preoperative preparations, uniform success was not achieved in securing ideal operating conditions following the use of thiouracil.

3. A later report will discuss toxic reactions to thiouracil with special reference to its use in preparing these one hundred patients for surgery.

4. We are acquainted with the methods of preparation suggested at a later date by other surgeons working with large groups of patients in preparation for surgery, and it should be noted that this series begins with a patient operated upon in July, 1943.

5. We are planning at a later date to report on the use of 6-propyl thiouracil in preparing patients for surgery. Our preliminary results show that this drug, in proper combination with iodine, appears to be much more satisfactory than its precursor thiouracil.



## THE PERFORATED APPENDIX\*

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IN almost all cases death from appendicitis follows perforation of the appendix which is unquestionably the most common source of peritonitis. In children it is responsible for over 90 per cent of the cases. In view of the incidence of appendicitis it is necessary to evaluate periodically the diagnostic signs and treatment of appendiceal perforation.

Of 1,158 cases of appendicitis seen at the University of Oklahoma Hospitals over a nine-year period ending April 1, 1948, the diagnosis of perforation was made in 197 cases.

From the duration of pain and certain physical findings, perforation may be suspected. The pulse rate is usually increased and leukocytosis appears early. The temperature is of no significance unless it exceeds 102.5°F. In the adult rectal tenderness and muscular rigidity are almost constant findings. Brenner<sup>1</sup> asserts that in children muscular rigidity is unreliable because of the undeveloped structures and that a hypersensitiveness of the overlying skin is often more conclusive. Scott and Ware,<sup>2</sup> reporting cases of perforative appendicitis in children, elicited involuntary muscle spasm in 94 per cent of the cases. Spreading tenderness is probably the most valuable sign of diffuse peritonitis; a mass in the lower abdomen denotes an abscess.

The treatment for most peritoneal inflammations is based on the natural resistance to bacterial invasion after the source of contamination is removed. Statistics disclose a rapidly progressing incidence of peritonitis twenty-four hours after perforation. Operative mortality after forty-eight hours is rated as high as 70 per cent by some authors. Usually after sixty

hours the infection is contained in an abscess or general peritonitis is established. In 1921 Ochsner<sup>3</sup> described a conservative type of treatment which had wide acceptance even before penicillin was available. Many surgeons recommend it for appendicitis of fifty hours' duration. Bailey<sup>4</sup> records only one fatality in ninety cases in which the patients were treated conservatively. Ideal candidates are the patients with a non-expanding palpable mass in the right lower abdomen and patients with diffuse peritonitis.

A study of 197 cases of appendicitis with perforation is presented. The cases are divided with respect to the degree of peritoneal involvement and the type of treatment elected. Table I shows the degrees of peritoneal contamination demonstrated clinically or at operation and the mortality rate with each. There were nineteen deaths in this series, a mortality rate of 9.6 per cent.

Of the 197 cases, fifty patients were treated conservatively. Forty-one presented clinical evidence of an appendiceal abscess. Complications occurred in ten cases, disclosing an incidence of 20 per cent. In five cases the presence of abscesses elsewhere in the peritoneal cavity was noted. There were seven deaths in this group, a mortality rate of 14.0 per cent.

One hundred forty-seven patients were treated surgically. There were twelve deaths, a mortality rate of 8.1 per cent. In forty-four cases, 30 per cent, abscess cavities in various stages of development were discovered. The operative results are summarized in Table II. Of the twenty-five patients treated with drainage of the abscess without removal of the appendix,

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three patients required a repetition of the procedure.

The incidence of postoperative complications was 25.5 per cent. Most complications occurred as the direct result of the infection. Abscess formation elsewhere in

slight. Penberthy<sup>3</sup> attempts to distinguish between contamination of the peritoneum and diffuse inflammation. In a fifteen-year survey of appendicitis he placed the operative mortality of the unruptured appendix at 0.4 per cent, the ruptured appendix at

TABLE I  
ANALYSIS OF CASES WITH RESPECT TO PERITONEAL INVOLVEMENT

Peritoneal involvement	No. of Cases	No. of Deaths	Mortality Rate (per cent)
Diffuse peritonitis.....	24	10	41.4
Appendiceal abscess.....	85	7	8.2
Local inflammation.....	88	2	2.2
Totals.....	197	19	9.6

the peritoneal cavity was observed in eleven cases. The incidence of pulmonary complications was 4.7 per cent.

Not including those who received penicillin, all patients in this series were given sulfonamide therapy in accordance with the standard practice at the time of hospitalization. The effect of penicillin on mortality was not remarkable. Forty-four of the 197 patients received penicillin doses varying from 50,000 to 100,000 units every two to three hours. There were four deaths in this group, a mortality rate of 9.0 per cent. Of the 153 patients who did not receive penicillin, fifteen deaths were recorded. The mortality rate was 9.8 per cent. Penicillin reduced the incidence of complications as shown by the fact that only 11.3 per cent of the patients treated with the drug had complications. The greatest reduction occurred in pulmonary complications. In the group not receiving penicillin the incidence of complications was 27.4 per cent.

The mortality rate in this series of 197 cases was 9.6 per cent. The average mortality rate for all diffuse peritonitis cases is between 5 and 15 per cent. This figure is probably diluted by many cases in which soiling of the peritoneal cavity was only

TABLE II  
ANALYSIS OF CASES TREATED SURGICALLY

Type of treatment	No. of Cases	Incidence of Complications (per cent)	No. of Deaths	Mortality Rate (per cent)
Appendectomy with drainage.....	109	23.8	9	8.2
Drainage without appendectomy.....	24	33.3	3	12.5
Appendectomy without drainage.....	14	21.5	0	0
Totals.....	147	25.5	12	8.1

5.5 per cent and perforation with peritonitis at 64 per cent.

#### COMMENT

The power of the peritoneum to resist infection is demonstrated by the number of cases with local inflammation and abscess formation following appendiceal perforation and their low mortality. It is further illustrated by the absence of a single fatality in fourteen cases in which the appendix was removed without drainage. Unrestrained soiling probably accounts for the poor results with simple drainage. These figures indicate that although contamination of the general peritoneal cavity should be prevented it is important to stop the source of infection by removing the appendix.

The mortality rate for those patients treated conservatively was 14.0 per cent; for those treated surgically it was 8.1 per cent. In view of the small margin between mortality rates with and without penicillin,

these comparisons advise careful selection of patients for conservative treatment.

#### SUMMARY

A review of 197 cases of perforative appendicitis is presented. Salient points in the diagnosis and treatment are examined. Statistics are presented which emphasize the natural resistance of the peritoneum and advise caution in the selection of cases for conservative management.

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OCCASIONALLY the ileum is involved and obstructed by endometriosis. The most common condition found is adhesions between the ileal loops although occasionally the endometriomas themselves may penetrate the bowel wall and impinge into the lumen. Patients with this condition give a suggestive history of sterility for many years, an acquired dysmenorrhea becoming progressively worse, clinical symptoms which become aggravated periodically during menses and presence of bimanual pelvic examination of several tender masses, especially in the posterior cul-de-sac. At surgery it is occasionally necessary to excise the involved bowel as well as to remove the ovaries with or without removal of the uterus. If one could be 100 per cent sure of the diagnosis, which one cannot, radiation therapy alone would suffice. (*Richard A. Leonardo, M.D.*)

## A POSSIBLE MECHANISM OF POSTCORONARY SHOULDER PAIN

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PAIN in the shoulder and upper extremity as a result of myocardial infarction has been described by a number of observers. This pain has been variously ascribed to bursitis, tendinitis, peri arthritis, cervical rib and osteoarthritis of the cervical spine.

Thus Askey,<sup>1</sup> from an observation of twenty-two cases, concluded that there was an "acute or subacute peri arthritis of one or both shoulders" which, in some cases at least, was attended by changes in the palmar aponeurosis. These palmar changes have been noted by others and have been diagnosed<sup>3</sup> as Dupuytren's contracture. Powers<sup>5</sup> thought the condition was "usually an effect of past or present visceral disease, producing irritation of the sympathetic system." Kehl<sup>3</sup> states "the changes in the palmar fasciae, closely resembling Dupuytren's contractures, and the coronary vascular accident bear a definite relation to each other." In the six cases observed by this author trauma did not seem to be a factor. As to the mechanism, no definite statement was made except that "the sympathetic nervous system appears to play a part as evidenced by the associated parasthesias and color changes."

In Boas and Levy's<sup>2</sup> six cases there was pain on motion of the shoulder which led them to suggest that the syndrome resembled "peri arthritis of the shoulder." In this they agreed with Howard,<sup>7</sup> one of the first to call attention to the association of coronary disease and shoulder pain which he interpreted as being due to peri arthritis.

On the other hand, Edeiken and Wolferth<sup>6</sup> who studied a group of fourteen patients with "persistent pain in the shoulder region following myocardial in-

farction," did not find any evidence of peri arthritis. They also stated, "There appeared to be no impairment of strength of the shoulder muscles, no atrophy and no sensory changes. No vasomotor changes were noted and no differences in the pulses on the two sides were found." They suggested that the pain mechanism was causalgic in nature. The pain may develop days, weeks or months following the myocardial infarct. It would appear, therefore, that the syndrome of painful shoulder following coronary occlusion could be divided into two groups as follows:

*Group 1.* Trophic disturbances develop with changes resembling peri arthritis of the shoulder joint. Motion becomes painful and limited. The referred pain may be causalgic or burning in nature and structures about the shoulder joint may undergo atrophy. Contracture of the palmar fascia may develop with physical signs identical with those of a Dupuytren's contracture.

Steinbrocker has made a comprehensive study of this type, suggesting the term "shoulder-hand syndrome." He described it as a form of reflex dystrophy and suggested the following mechanism:

The reflex starts from an area of local tissue disturbance such as a traumatized extremity, a myocardial infarct or the site of a cerebral lesion. Impulses from these areas travel centrally along the usual afferent pathways and enter the internuncial system of neurons within the spinal cord. This is an interconnected and widely ramified network of neurons and nerve fibers within the central nervous system. Ordinarily, incoming nerve impulses travel along specific pathways or tracts of this network to reach predetermined efferent neurons.

In the shoulder-hand syndrome the impulses apparently set up a central disturbance in the nature of a widespread, continuous agitation of the internuncial pool. Impulses spread steadily to stimulate anterior horn and lateral horn cells not ordinarily affected by afferent impulses from the various lesions. This incessant stimulation is expressed peripherally by motor and neurovascular symptoms. Muscle spasm and vasomotor imbalance result and produce the characteristic clinical features of the shoulder-hand syndrome. Treatment for the shoulder-hand syndrome is repeated stellate ganglion infiltration with procaine.

*Group 11.* Pain is referred to the neck, shoulder and upper extremity without trophic changes. There is no pain on motion nor is movement of the shoulder joint restricted. In this group there are two types of references: (1) The pain is reflexly referred to the neck, shoulder and as far as the proximal half of the upper arm ( $C_3$ ,  $C_4$ ,  $C_5$ ). (2) The pain is referred to the neck, shoulder and entire upper extremity and is often associated with burning, tingling and a sensation of numbness in the hand and fingers. The shoulder and arm feels heavy and tired; the patients complain that they cannot find a place for it. The dorsum of the wrist may become sore and the gripping power of the hand is often diminished. Pain is usually worse at night. Diffuse tenderness may be present.

That these two groups of pain are different in mechanism and nature and are not different stages of the same mechanism is indicated by the fact that trophic changes and limited motion develop in one and not in the other. Also, the mechanism that causes pain in the distribution of  $C_3$ ,  $C_4$  and  $C_5$  is not likely to cause a direct reflex reference to the lower arm and entire hand. In Group 11 the pain, although severe and chronic, does not eventually cause atrophy and limited motion of the shoulder joint. Again, in the first group, treatment soon after the onset of pain is difficult and response is slow if at all. However, in type

(2) of Group 11 relief of pain is obtained almost immediately even in cases of chronic duration. The clinical picture presented in this type is that of a scalenus anticus syndrome. The anterior scalene muscle is more tense and full than the unaffected side. Pressure at its insertion causes radiation with intensification of the original complaint. Using the hyponeedle technic the muscle is infiltrated with 1.5 cc. to 2 cc. of 2 per cent procaine and the pain disappears completely within a three-minute period. This immediate response fulfills the criteria we have suggested for a diagnosis of an anterior scalene syndrome, namely, complete disappearance of pain within a three-minute period without anesthesia of any portion of the brachial plexus and without the presence of a Horner's syndrome.<sup>9</sup>

#### CASE REPORT

D. S., a white male, aged sixty-one, came to us on May 5, 1947. The report of his physician in December, 1946, gave a history of abnormal breathlessness on walking for the past five years. In December, 1945, he experienced recurrent, mild, epigastric pain radiating up to the sternum to the left shoulder. Because of an episode of syncope he was hospitalized in October, 1946. Five or six weeks later pain developed in his shoulder and upper arm only; this lasted four weeks and then disappeared. The electrocardiogram revealed frequent ventricular extrasystoles, negative T waves in leads I and  $CR_3$  to  $CR_5$  and evidence of chronic myocardial injury. Blood pressure was 120/65; pulse rate 76. Examination of the heart by orthodiagraph showed marked left ventricular enlargement; the rhythm was very irregular due to frequent ventricular premature contractions. Sounds were distant; rough systolic murmur was heard at the base. The diagnosis was arteriosclerotic heart disease with cardiac enlargement, coronary sclerosis and healed anterior myocardial infarct. At the end of December he had another coronary attack and remained in bed for ten days. Two weeks following the onset of this attack he experienced pain in the lower arm and fingers for the first time.

The patient's chief complaint when examined by us was pain in the left shoulder, arm

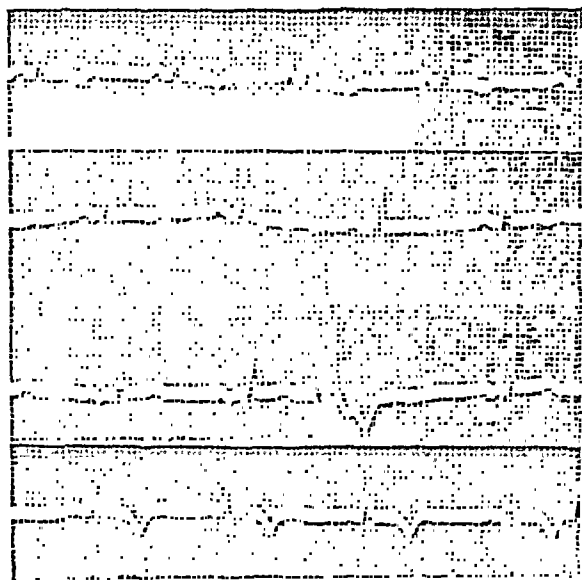


FIG. 1. Rate 72; irregular due to occasional premature contractions; P-R interval 0.18 second; P waves notched or diphasic in all leads; QRS duration 0.06 second; QRS complexes slurred or splintered in all leads; occasional ventricular extrasystoles; T waves inverted in leads I, II, and IV, upright in III; R-T or S-T deviation none; direction of electrical axis normal. Interpretation: (1) old anterior coronary occlusion, (2) severe myocardial disease.

and hand for the past four months. Associated with this was a sensation of numbness and tingling in the left hand. The gripping power of the hand was impaired. The entire shoulder, arm and hand had a sensation of heaviness or excessive weight. During the day he was fairly comfortable but at night his pain became extremely severe. He had not had a night's rest for six weeks.

Examination revealed a tense, tender scalenus anticus muscle on the left. Pressure on the lower end of the muscle above the clavicle caused severe pain and radiation into the shoulder, arm and hand reproducing and intensifying those symptoms of which he complained. Electrocardiographic studies were repeated at this time. (Fig. 1.) These studies showed evidence of severe myocardial damage and occasional ventricular extrasystoles. The damage seemed to be on the basis of an old anterior coronary occlusion confirming the report of the previous electrocardiogram.

The scalenus anticus muscle was injected with 1.5 cc. of 2 per cent procaine. The patient reported back three days later stating that he had had no pain since the day of his injection. Tingling and numbness disappeared and

strength of the grip was restored. There was a slight recurrence of pain at the end of two weeks and the injection was repeated.

#### COMMENTS

Pain referred from the diaphragm and pericardium to the trapezius ridge of the shoulder has been reported in the literature.<sup>18</sup> We were unable, however, to find any reference to a mechanism whereby pain was referred from the central diaphragm and pericardium to the neck, shoulder, lower arm and hand. It is our belief that the mechanism of a scalene syndrome following a myocardial infarct has its origin in the pericardium and that it occurs as a sensorimotor reflex mediated by the phrenic nerve. The phrenic, a mixed spinal nerve, is derived mainly from C<sub>4</sub> with branches from C<sub>3</sub> and C<sub>5</sub> segments. The scalenus anticus muscle is innervated by branches from C<sub>4</sub>, C<sub>5</sub> and C<sub>6</sub> segments.

When a myocardial infarct takes place, the resultant pericarditis irritates the sensory endings of the phrenic nerve. This in turn causes an intrasegmental reflex reference of pain in the sensory distribution of C<sub>4</sub>, C<sub>5</sub> and C<sub>6</sub> segments. This causes pain which may be referred to the neck, shoulder girdle and proximal half of the upper arm (Group II, type (1)).

If the stimuli are adequate, a spasm of the anterior scalene muscle develops as a reflex, possibly axonal in mechanism. As a result additional symptoms develop which involve the entire upper extremity (Group II, type (2)). We have commonly observed this mechanism in other lesions which involve the shoulder girdle segments. For example, in subdeltoid bursitis or supraspinatus tendinitis of the shoulder the pain is first localized to the region of the shoulder joint. Later it is often referred to the lower arm and hand because of a reflex scalene spasm which is superimposed upon the primary source of pain. Infiltrating the scalene muscle with procaine causes the reflex scalene syndrome to abate or disappear although the primary source of pain is not affected. In the same manner the pain of a

reflex scalene syndrome following myocardial infarction disappears although the pericardial irritation has not been influenced. Others as well as we ourselves have reported primary scalenus anticus syndromes simulating the pain of coronary disease. We have also demonstrated electrocardiographic changes induced by compression of the anterior scalene muscle in patients suffering from this syndrome.<sup>10</sup> From the evidence we have just presented it would appear that a scalene syndrome may not only simulate the pain of coronary disease but that it possibly may be caused by myocardial infarction.

This reflex mechanism from a pericarditis via the phrenic nerve which initiates a secondary scalene syndrome is no different from the reflex scalene syndrome which is initiated by a bursitis or tendinitis of the shoulder. Both are referred by a spinal nerve to the segments of C<sub>4</sub> and C<sub>5</sub> (phrenic, C<sub>3</sub>, in addition) and both are initiated by sensory impulses which originate in structures supplied by somatic nerves. We believe that this mechanism is possibly the cause, also, of anginoid pain caused by diaphragmatic hernia and other lesions in this vicinity. The phrenic nerves also have intra-abdominal branches which pass to the celiac plexus and suprarenal glands. The right phrenic nerve sends branches to the falciform and coronary ligaments of the liver and the inferior vena cava. Branches of both phrenic nerves have been described as going to the peritoneum.

By using faradic current we were able to stimulate the left phrenic nerve close to the diaphragm in a dog. At each contact the neck muscles were thrown into a reflex spasm, there being no structures in the neck directly supplied by the phrenic nerve. Therefore, the phrenic nerve is a pathway, which could explain the anginoid symptoms which accompany upper abdominal

lesions. Pain could be referred from here to the central diaphragm, the precordial area (pericardial supply) as well as to the shoulder girdle and, finally, by a reflex scalene spasm (especially in acute pain) could be referred to any part of the upper extremity. Anginoid pain from diaphragmatic hernia also could be explained on this basis.

We suggest this as one of several mechanisms which possibly cause persistent shoulder pain. The pathways involved are somatic as contrasted to the sympathetic or dystrophic types which are associated with limitation of motion of the shoulder joint and hand.

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# ANESTHESIA FOR EXTREMITY AMPUTATIONS\*

## A STATISTICAL REVIEW OF 185 MAJOR AMPUTATION CASES

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ONE hundred eighty-five amputations have been presented in an attempt to establish the relationship of mortality and morbidity to the anesthetic agents employed. The preoperative condition of the patient seems to be the most important factor in determining the outcome. A mortality of 14.05 per cent occurred in this series. All of these deaths were in patients in poor preoperative condition. Seven per cent of the fatalities occurred in the thirty days following operation and 7 per cent occurred after this thirty-day period. Ethylene-oxygen is our anesthetic of choice for amputations.

Patients requiring amputation of an extremity usually present some particular constitutional defect which increases the hazard of surgery and anesthesia. These patients frequently need the special attention of the internist, surgeon and anesthesiologist. Many are well past middle age and have some dysfunction of the cardiovascular system such as generalized arteriosclerosis or hypertension. Often they present a chronic condition such as diabetes or secondary anemia which has been neglected or haphazardly treated. Previous literature reports, including the disease process, anesthetic employed and mortality rate, are summarized in Table I.

The results of our experience in 185 patients can be found in Table II. Very few operations in our series were performed for traumatic wounds in normally good risk patients. This differs from war injuries. Fifty-two patients in our series had a preoperative diagnosis of diabetes, forty-one had malignancy of bone or skin of the extremity and twenty-eight had arterioscle-

rotic gangrene. A much larger group had hypertension, three had untreated lues, one had amebic dysentery, one had carcinoma of the kidney, fourteen had marked secondary anemia, five had endarteritis obliterans, one had a popliteal aneurysm, one had far advanced scleroderma, two had active pulmonary tuberculosis, one had lobar pneumonia and two had gas gangrene of the extremity.

Age distribution appears in Table III.

Six deaths occurring after thirty days, but within six months after surgery, were attributed to circulatory failure or cardiovascular accidents (Table IV.) Six deaths occurring more than six months after surgery were the results of metastasizing sarcomas or carcinomas for which the amputation had been originally performed. One death occurred four months postoperatively, the cause unknown.

Table V presents the relation of mortality to the type of anesthesia employed.

Inhalation anesthesia was administered to 169 or 91.3 per cent of the patients. (Table VI.)

Local anesthesia was used for only those individuals in an extremely serious condition and thus was necessarily associated with a high mortality rate.

### COMMENTS

Veal<sup>23</sup> stated that the incidence of pulmonary complications following thigh amputations is out of proportion to similar conditions in other fields of surgery and reported a 14.4 per cent mortality from postamputation pulmonary complications. He advocated high ligation of the femoral vein as a preventive measure. Glasser and

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TABLE I

Author and Year	Total No. Amputations	Disease Process	Anesthetic	No. of Deaths and Per Cent of Mortality
de Takats, G. and Reynolds, J. T. <sup>1</sup> February, 1940.	50	Mixed: diabetes, peripheral vascular disease with gangrene	Spinal 38 Ethylene-oxygen 10 Pentothal 2	14 deaths, 28% mortality 2 bronchopneumonia 2 coronary occlusion 1 delayed shock 8 sepsis
Crossman, L. W., Ruggiero, W., Hurley, V. and Allen, F. M. <sup>2</sup> January, 1942.	57 (45 patients)	Diabetic gangrene	Refrigeration	7 deaths, 12.3% mortality
Crossman, L. W., Allen, F. M., Ruggiero, W., Hurley, V. and Warden, C. <sup>3</sup> February, 1942.	58	Diabetes and arteriosclerosis	Refrigeration	7 deaths, 13% mortality
Conway, H. and Meigher, S. C. <sup>4</sup> March, 1942.	46	All diabetics: arteriosclerosis, fever, gangrene and infection	Spinal 60	9 deaths, 19.56% mortality
Donahue, F. M. <sup>5</sup> March, 1942.	21	Diabetic gangrene	Spinal 6 Gas-oxygen-ether 10 Cyclopropane 3	5 deaths, 23.7% mortality
Pennayer, G. P. <sup>6</sup> March, 1942.	40	Diabetic gangrene	Spinal 19 Gas-oxygen-ether 4 Nitrous oxide-oxygen 2 Ether 1 Cyclopropane 1	4 deaths, 10% mortality
Solley, I. V. <sup>7</sup> March, 1942.	34	Diabetic gangrene	Not listed	9 deaths, 26.5% mortality
Macey, H. B. and Bickel, W. H. <sup>8</sup> April, 1942.	240	Occlusive arterial disease	Spinal	24 deaths, 10% mortality
Theis, F. V. <sup>9</sup> January, 1943.	79	Advanced arterial disease	Ethylene-oxygen 77 Local and block 2	24 deaths, 32.7% mortality
Nixon, E. A. <sup>10</sup> May, 1943.	5	Buerger's disease, <sup>1</sup> Diabetes and gangrene, <sup>1</sup> Arteriosclerosis, <sup>2</sup> Arteriosclerotic gangrene, <sup>1</sup>	Refrigeration	2 deaths, 40% mortality
Johnson, M. D. <sup>11</sup> May, 1943.	8	Diabetes and arteriosclerotic gangrene	Refrigeration	6 deaths, 37.5% mortality
Mock, H. E., Mock, H. E., Jr. <sup>12</sup> May, 1943.	17	Peripheral vascular disease, 8 Trauma, 9	Refrigeration	2 deaths of 8 1 acute coronary thrombosis 2 sepsis No deaths of 9 11% mortality
Glasser, S. T. and Mersheimer, W. L. <sup>13</sup> November, 1943.	17	Diabetic gangrene Arteriosclerosis	Refrigeration	6 deaths, 38.8% mortality
Massie, F. M. <sup>14</sup> January, 1944.	14	Mixed: arteriosclerosis diabetes sarcoma cardiorenal Buerger's chronic osteomyelitis	Refrigeration	4 deaths, 28.5% mortality



TABLE I (Continued)

Author and Year	Total No. Amputations	Disease Process	Anesthetic	No. of Deaths and Per cent of Mortality
O'Neil, E. E. <sup>15</sup> February, 1944.	50	Arteriosclerotic gangrene Diabetes Sepsis Cardiac failure	Refrigeration	16 deaths, 32% mortality
Mock, H. E. and Tannehill, E. H. <sup>16</sup> April, 1944.	2	Trauma, fractures of pelvis complicated by gangrene of extremity	Refrigeration	No deaths
Miyakawa, G. <sup>17</sup> December, 1944.	9	Mixed: trauma 2 gangrene 1 Diabetic arteriosclerotic	Refrigeration	2 deaths, 22% mortality
Scharr, C. M., Jones, D. D. and Tehan, T. R. <sup>18</sup> December, 1944.	53	Mixed: severe trauma arteriosclerosis diabetes thromboangiitis	Local 5 Spinal 37 Pentothal 1 Refrigeration 9	4 deaths, 7.5% mortality
Horner, H. O. <sup>19</sup> November, 1945.	12	Arteriosclerosis Peripheral vascular disease Gangrene Diabetes	Refrigeration	2 deaths, 16% mortality*
Melick, D. W. <sup>20</sup> December, 1945.	93	Diabetes Diabetes Arteriosclerotic gangrene	23 Refrigeration 70 Cyclopropane Spinal 60% Nitrous oxide 16% Pentothal 12% 7%	4 deaths, 17.3% mortality 13 deaths, 18.4% mortality
Mandelberg, A. and Sheffield, W. <sup>21</sup> January, 1946.	128	Diabetic gangrene	43 Spinal 85 General	43 deaths, 32.8% mortality
Tobias, M. J. <sup>22</sup> March, 1946.	149	Diabetic gangrene	94 Refrigeration 17 Spinal 38 Cyclopropane	36 deaths, 38.2% mortality 5 deaths, 29.4% mortality 8 deaths, 21.05% mortality

\* Mortality under refrigeration almost twice that of ether, cyclopropane or spinal.

Mersheimer<sup>13</sup> cited pneumonia and pulmonary embolism as a frequent cause of diabetic amputations under general and spinal anesthesia Mandelberg and Shef-

TABLE II  
OPERATIVE RISK IN 184 AMPUTATION CASES

Risk	Patients	Per cent
Good.....	30	16.0
Fair.....	58	32.3
Poor.....	71	39.0
Serious.....	21	12.3
Emergency good.....	2	0.1
Emergency poor.....	3	0.2
	185	99.9

death in their series of seventeen amputations under refrigeration anesthesia, with a mortality of 38.8 per cent. In a series of

TABLE III

Years	No.
0-9	9
10-19	17
20-29	16
30-39	16
40-49	27
50-59	43
60-69	36
70-79	19
80-89	2
Total	185

field<sup>21</sup> encountered an incidence of 7 per cent postoperative pulmonary complications. Samuels<sup>24</sup> reported a sudden postoperative pulmonary mortality of 5 per cent. The preoperative condition of the

patient and the surgical technic were considered more important by these authors than the anesthetic agent employed

In our study fatal pulmonary embolism occurred in seven patients within thirty days postoperatively and in one patient

TABLE IV  
MORTALITY

	Within 30 days	After 30 days
Pulmonary embolism.....	7	1
Coronary thrombosis.....	1	2
Cerebral embolism.....	2	1
Circulatory failure.....	3	2
Metastatic carcinoma or sarcoma..	0	6
Unknown.....	0	1
	13	13

TABLE V  
RELATION OF MORTALITY TO ANESTHETIC AGENT

Agent	Patients		Deaths			
	No.	Per cent	Within 30 Days		After 30 Days	
			No.	Per cent	No.	Per cent
Ethylene-oxygen....	135	72.9	9	6.6	10	7.4
Ethylene-oxygen-ether.....	23	12.4	0	0	2	8.6
Spinal.....	11	5.9	1	9.8	0	0
Local.....	5	2.7	3	60.	1	20.
Others.....	11	5.9	0	0	0	0
Total.....	185	99.8	13	7.0	13	7.0

after the thirty-day period. These fatal cases were all classified preoperatively as poor to serious risks. Five of these individuals received ethylene-oxygen anesthesia; two received local anesthesia. Three patients died within the first forty-eight hours; in the remaining four individuals embolism occurred from six to thirty days postoperatively. The anesthetic course was uneventful in all but two of these patients with fatal pulmonary embolism. Of these

two, one patient was a male, aged seventeen, with gangrene and chronic osteomyelitis of the right femur. A mid-thigh amputation was performed under local infiltration with 1 per cent procaine hydrochloride. Eleven minutes after surgery

TABLE VI  
ANESTHETIC AGENT

Ethylene-oxygen.....	135
Ethylene-oxygen-ether.....	23
Ethylene-oxygen-local procaine.....	4
Ethylene-oxygen-sodium pentothal.....	3
Intravenous pentothal.....	2
Rectal pentothal.....	1
Ethylene-oxygen-nitrous oxide.....	2
Nitrous oxide-ether.....	2
Spinal—single injection.....	10
Procaine.....	9
Nupercaine.....	1
Continuous spinal procaine.....	1
Local infiltration only—procaine.....	5
Total.....	185

began the patient complained of difficult breathing and the respiratory rate rose from 32 to 72 a minute. The blood pressure was unchanged throughout. Pulmonary embolism was suspected at the time. The patient expired seven hours postoperatively and autopsy confirmed the clinical impression of massive pulmonary embolism. The other patient in whom anesthetic difficulties occurred was a forty-seven year old white male with hypertensive cardiovascular disease, chronic glomerulonephritis, embolism of the left popliteal artery with gangrene of the left foot and leg. A mid-thigh amputation was performed under ethylene-oxygen anesthesia. The patient was cyanotic throughout, requiring an anesthetic mixture high in oxygen and on two occasions he became apneic. The patient expired two weeks later following an episode of severe dyspnea and cyanosis; the clinical diagnosis was pulmonary embolism, but no autopsy was obtained.

Circulatory failure associated with anesthetic complications developed in one patient who expired nine hours after a mid-thigh amputation. The patient was a white male, aged seventy, whose preoperative condition was poor. The preoperative diagnosis was diabetes, nephrosclerosis,

arteriosclerotic heart disease and active stomach ulcer. Ethylene-oxygen anesthesia was administered; twenty-five minutes after surgery began the patient suddenly became cyanotic and his respirations were slow and grasping. Within five minutes his color improved and his respirations became regular. However, the blood pressure remained low throughout and the pulse was slow with many extrasystoles. Nevertheless, the immediate postoperative condition of the patient was fairly good. Nine hours later the patient became comatose, pulseless and died within a few minutes. Autopsy revealed acute dilatation of the heart.

Cerebral embolism occurred in two of the patients who expired within thirty days after amputation. In one individual, a fifty year old white woman who had a preoperative diagnosis of diabetes mellitus and arteriosclerotic heart disease, the cerebral accident occurred four days postoperatively. She died ten days later and at necropsy hypostatic pneumonia complicating right cerebral thrombosis was found. Ethylene-oxygen anesthesia in her case was uneventful. Hypertensive cardiovascular disease, diabetes, chronic glomerular nephritis and gangrene were present in a sixty-two year old white male who had a mid-thigh amputation under ethylene-oxygen anesthesia. The systolic blood pressure was elevated to 200 to 210 mm. of mercury throughout. Six hours postoperatively he became comatose and he died twelve hours later. No autopsy was obtained but the clinical cause of death was considered to be a cerebrovascular accident.

In retrospect, it seems possible that a few of these patients might have had a better chance for recovery had refrigeration anesthesia been employed. Refrigeration anesthesia is said not only to permit postponement of the surgical procedure until the general condition of the patient improves but also to retard postoperative infection. Tobias,<sup>22</sup> however, states that the incidence of gas bacillus infection is high

with use of refrigeration anesthesia. In our series, when refrigeration anesthesia was not used, postoperative wound infection occurred in thirteen patients, or 7 per cent. Of these thirteen individuals five patients had diabetes mellitus; three, arteriosclerotic gangrene; three, carcinoma of the skin; one, carcinoma of the bone and one, chronic osteomyelitis. Evaluation of the preoperative risk in these thirteen patients was as follows: nine, poor; two, fair and two, good. Ethylene-oxygen was administered to eleven and spinal anesthesia to two. It is interesting to note that only three moderate to severe postoperative wound infections occurred in our series prior to 1939, or the introduction of modern chemotherapeutic agents.

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IN bad risks in whom a limb must be sacrificed because of gas bacillus infection or for other good reasons, the pathologic process may often be stopped by the application of a tight tourniquet. The surgeon can later do a guillotine or a classical amputation if and when the patient's general condition improves. Odor from the gangrenous limb below the site of the tourniquet can be prevented by formaldehyde solution. S. R. Maxiner also wraps the extremity in rubber and finds this very efficacious in rendering this whole technic odorless. Occasionally, surgeons may find good use for this procedure. Refrigeration of the extremity is also very efficacious, of course, but it involves more work for the nurses and attendants unless an electric refrigerating apparatus is being used. (*Richard A. Leonardo, M.D.*)

# PREVENTION OF POSTOPERATIVE PULMONARY COMPLICATIONS\*

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**M**OST postoperative pulmonary complications in general surgery can be prevented by careful preoperative evaluation and preparation of the patient, proper choice and administration of the anesthetic agent, gentle surgical technic

TABLE I  
POSTOPERATIVE PULMONARY COMPLICATIONS  
Type of Procedure

Type of Procedure	No.
Upper abdominal.....	82
Lower abdominal.....	193
Appendectomies.....	196
Hernia repairs.....	54
Thyroidectomies.....	30
Rectal.....	61
Vaginal {majors—23 } {minors—69 }	92
Miscellaneous minor.....	132
Plastic.....	58
Saphenous ligations.....	43
Miscellaneous major.....	19
Total.....	960

and an adequate prophylactic postoperative regimen.

We wish to present in this paper a series of 960 operative cases (Table I) during the past two years with consideration of the prevention of postoperative pulmonary complications and a discussion of the factors involved.

## COMPLICATIONS

The pulmonary complications in order of their frequency of occurrence will be discussed:

1. Atelectasis is the collapse of a portion of the lung. It may occur as the collapse of multiple lobules, usually on one side and usually in the lower lobe or as the collapse of one or more lobes of the lung. Not infrequently there may be a collapse

of both lower lobes. The etiology is usually failure of the patient to inflate the entire lung adequately or mechanical obstruction to a portion of the lung preventing adequate inflation. In our series we have had two cases of minimal atelectasis which responded rapidly to penicillin by nebulizer and to deep breathing stimulated by a mixture of carbon dioxide and oxygen.

2. Postoperative pneumonia is usually of the lobular type and is almost always the result of some other condition. The more common sources of postoperative pneumonia are atelectasis, pulmonary infarction from peripheral emboli, pre-existing lung infection, cardiac failure in elderly people and the aspiration of gastric contents. There were two cases of postoperative pneumonia in our series which responded rapidly to penicillin parenterally and by nebulizer. One of these was the case of a twelve year old boy who had an acute suppurative appendix and chronic bronchiectasis. The appendectomy was done under spinal anesthesia.

3. Postoperative pulmonary infarction results from occlusion of the blood supply to a portion of the lung by an embolus or emboli from the peripheral circulation. It may vary from a very minimal infarction to a massive one in which death is an immediate result. An infarct may clear up without further trouble or pneumonia or a lung abscess may result. The one case of pulmonary infarction in our series occurred in a patient with a gunshot wound of the thigh, including a hip fracture which the orthopedist treated by well-leg traction with both legs incorporated in plaster casts. He was treated with penicillin parenterally

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and by nebulizer and with the sulfonamides and recovered without incident.

4. Postoperative pulmonary abscess occurs following aspiration of gastric contents or as an end result of pulmonary infarction. There were no cases in our series.

*Evaluation and Preparation of Patient.* The following steps should be strictly followed: (1) A history with special reference to previous pulmonary disease should be taken; (2) a physical check with thorough examination of heart and lungs should be done; (3) a complete blood count and urinalysis should be made; (4) penicillin by nebulizer should be administered if there is slight upper respiratory infection or if there is a history of pre-existing lung disorder. Surgery should be deferred if possible in cases of more severe or extensive respiratory infection. (5) Nothing should be given by mouth preoperatively for eight to ten hours if possible. The stomach should be aspirated prior to surgery for intestinal obstruction or congenital pyloric stenosis. (6) Atropine or scopolamine should be administered in adequate dosage to reduce the mucous secretion effectively. (7) The nutritional status of the patient should be evaluated and corrected if necessary with intravenous fluid, amino acids, plasma or whole blood.

*Proper Choice and Administration of the Anesthetic Agent.* The following conditions are to be considered in the choice and administration of anesthesia: (1) Local or spinal anesthesia, if possible, in the presence of upper respiratory infection or pre-existing pulmonary disturbance; (2) spinal anesthesia for intestinal and upper abdominal work with general anesthesia and curare as an alternative; (3) adequate respiratory exchange during anesthesia; (4) prevent aspiration of vomitus during reaction from anesthesia; have suction machine available especially for children. (5) In the prone and the jack-knife positions, with special reference to rectal work, we believe that a low, well localized spinal or saddle block is definitely the anesthesia of choice.

August, 1949

#### GENTLE SURGICAL TECHNIC

The principles of gentle, careful surgery should be followed at all times and are especially important in abdominal surgery; for careless or rough handling of the bowel will tend to produce paralytic ileus postoperatively with resulting abdominal distention, which in turn may hamper or prevent full respiratory excursion and considerably increase the possibility of respiratory complications. Transverse incisions should be made whenever possible and feasible because they allow more freedom for respiratory excursion.

In pelvic surgery it is important to allow as little trauma as possible to the large pelvic veins.

It is also important to avoid extreme positions during the operative procedure, such as extreme lithotomy, deep Trendelenburg, prone, etc. This is especially important over long periods of time.

The avoidance of constricting dressings is another factor to be remembered.

#### POSTOPERATIVE REGIMEN

The postoperative regimen is most important and should consist of the following procedures:

Leg exercises should be initiated with particular reference to the calf muscles immediately after the patient returns to his room and every two to three hours thereafter for six or eight times or until the patient is out of bed or sitting on the side of the bed dangling his feet. These exercises consist of extending and dorsiflexing the feet ten times.

Deep breathing exercises should be carried out as soon as the patient reacts sufficiently and every two to three hours thereafter for six or eight times or longer if necessary. If the patient will not or cannot cooperate satisfactorily, inhalation with a carbon dioxide and oxygen mixture is used every four hours until the patient can breathe deeply enough without this stimulation.

Early ambulation is accomplished as soon as possible. Most of our patients sit on the side of the bed and dangle their feet in about eighteen to twenty-four hours postoperatively and are out of bed in about thirty-six hours. In a few cases in which it was necessary to delay ambulation, a high back rest was provided several times a day; the patient was turned frequently and the deep breathing and leg exercises were continued for as long as necessary. Patients who have had a saphenous ligation are out of bed and walking around six hours postoperatively.

The use of penicillin by nebulizer should be introduced in patients who had an upper respiratory infection prior to operation or had some pre-existing lung disorder or developed an upper respiratory infection after operation. A solution of 20,000 units of penicillin per cc. of normal saline is placed in the nebulizer and the patient takes six to eight deep inhalations while using the nebulizer every three to four hours. In most instances the penicillin was nebulized by means of the hand bulb, but it may also be used by attaching an oxygen tank with a gauge.

Heparin, dicumarol or other anticoagu-

lants were not used in this series of cases and will not be discussed.

#### SUMMARY AND CONCLUSIONS

1. A series of 960 operative cases over a two-year period is presented. This is believed to represent a good cross-section of a general surgical practice.

2. The most frequent postoperative pulmonary complications and the etiologic factors involved are discussed.

3. The principles to be followed in adequate regimen for the prevention of postoperative pulmonary complications are outlined.

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# OXYTOXICS IN LABOR

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RECENTLY it has been noted that numerous women with normal-term pregnancies have been delivered subsequent to previous stillbirths. These calamities were not caused by Rh factors or lues. It is difficult to determine whether or not the actual frequency of stillbirths has increased. As a rule review of records of this type of case is not permissible. Upon casual observation this finding seems to be on the increase. What is the cause? Could it possibly be the rush created by the scarcity of doctors during the war years? If so, were oxytoxics used more frequently? Or is it the influence of literature advocating the use of oxytoxic drugs in the first and second stages of labor for inertia and dystocia which is a responsible factor?

It is the author's belief that the use of oxytoxics in the first and second stages of labor should be carried out with the utmost caution. Full evaluation of the forces, passenger and passage should be known. It is our duty as physicians to see that the fetus makes a safe arrival through the maternal passages without injury to it or to the mother. When either is encroached upon we have failed. It is wrong to attempt to drive a fetus through a pelvis with oxytoxic drugs when there is the possibility of a disproportion being present; the outcome is too often disastrous. It is also wrong to give oxytoxics when the uterine tone is above normal as too often this type of uterus will go into a tetanic contraction, depriving the fetus of its blood supply by compressing the placenta too long. Uterine rupture may also result from the increased stimulus. This rupture may take place after the administration of only 2 minims of pituitrin or pitocin. Uteri may rupture without the use of these drugs; however, if

they were used, one could not help but put the blame on possible injudicious use of these agents. This is particularly true in the grand multipara in whom uterine rupture is not uncommon without the use of oxytoxic drugs.

It has been noted that pitocin or pituitrin has been ordered in the induction of labor with all discretion as to its use left to the nurse. Often the drug is administered in an ordinary 2 cc. syringe in doses of 3 minims and more at intervals from thirty to sixty minutes without regard to the action of the drug on a given uterus. It is known that often only  $\frac{1}{2}$  minim is needed to bring about the desired result and the amount need not be increased in subsequent doses in the induction of labor. Often only one dose is needed to initiate labor and when more is given, disastrous results may be had or, at best, no additional benefits are obtained. It is not unusual to see a uterus so "overworked" by the continued administration of oxytoxic drugs that it will cease to contract.

I am not advocating that the use of oxytoxic drugs be abandoned but I am making a plea for their more judicious use.

## INDICATIONS AND CONTRAINDICATIONS

1. If oxytoxics are to be used in the induction of labor, they should be given with a tuberculin syringe beginning with  $\frac{1}{2}$  minim doses and increased by  $\frac{1}{2}$  minim until the effective dose is reached. When this is accomplished, no further use of the drug is indicated. These drugs should be given by the physician in charge or a competent resident physician.

2. These drugs should not be given to patients with uteri presenting increased tone, having irregular contractions. If this type of patient is properly sedated and



given fluids, labor often will progress in a normal fashion.

3. Oxytoxic drugs should not be given when there is evidence of disproportion. Cesarean section is preferred and is more conservative.

4. Position of the fetus should be ascertained as malposition is often the cause of prolonged labor. This condition may be

corrected spontaneously or by relatively simple procedures. Administration of oxytoxics in these cases is injudicious.

5. Heart tones should be watched carefully during labor, particularly when the patient has been given pituitrin or pitocin. Occasionally a relatively simple procedure may save a baby when serious alteration in fetal heart tones are noted.



HYSTEOSALPINGOGRAPHY is very helpful in the diagnosis of sterility. It gives us an idea of the pathologic condition present in the tube or uterus and, occasionally, even of the condition present in the ovary. It not only demonstrates whether or not the tubes are patent but also gives us an idea where obstruction is present when it is. If the tube is patent throughout except at its fimbriated end, this portion may be resected and the new tubal ostium made suitable for reception of the monthly matured ovum. By hysterosalpingography we can also demonstrate uterine deviations and malformations and tumors when present. (*Richard A. Leonardo, M.D.*)

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# Streamlined Articles

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## ROLE OF ANESTHESIA IN GYNECOLOGIC SURGERY\*

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UPON determination of the need for operative procedures the gynecologic surgeon should start to appraise the patient for anesthesia in his office. He should determine the presence of idiosyncrasies and allergic manifestations to various drugs and foods, histories of previous reactions to anesthetic agents and the existence of disease in systems other than gynecologic. He should be aware of abnormalities in those organs which may interfere with proper absorption, detoxification and elimination of anesthetic agents. For example, pulmonary diseases may be considered as barriers to volatile inhalation agents passing through the alveolar membrane to the blood stream. Habits, such as alcoholism, which increase the resistance to anesthesia must be ascertained. The surgeon can assist also in overcoming resistance by allaying the patient's inherent fear and apprehension to the expected operation and anesthesia. He can instill confidence by briefly informing the patient about the type of operation contemplated, using simple, non-alarming terms and reassuring her that the anesthetic procedure will be carried out with the utmost regard for her safety and comfort. A simple physiologic approach can go a long way in making the administration of the anesthetic easier.

The patient should be admitted to the hospital early in order to determine and help to correct any abnormalities present that might interfere with the course of

operation and postoperative recovery. The red cell and hemoglobin values reveal the oxygen-carrying capacity of the blood. Nutritional deficiencies, dehydration and acidosis, if found, can be corrected by the use of intravenous electrolytes, glucose, vitamins and amino acids. A high vitamin B content<sup>1</sup> in the preoperative diet, has been known to reduce the toxic effect of the anesthetic agent on the body tissue. Metabolic abnormalities should be known; blood chemistry and urinary studies are necessary to evaluate kidney function.

Early admission of the patient to the hospital also enables the anesthesiologist to become acquainted with not only the factors which influence the management of the anesthetic course but also to reassure the patient that the anesthetic procedure will not be as formidable as she fears. A few kind and sympathetic words can do much to minimize untoward psychic reactions and permit the use of smaller amounts of preliminary sedation.

The anesthesiologist should decide on the pre-anesthetic medication and the anesthetic agent best suited for the patient during the visit on the day preceding the operation. Each patient is judged individually. The habit of routine orders of preoperative sedation can only be severely condemned. The purpose of sedation is to allay fear and apprehension, reduce reflex irritability (the resistance of the patient to anesthesia), raise the threshold of pain perception and reduce undesirable side

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effects of certain anesthetic agents. The preliminary agent should reduce the metabolic rate<sup>2</sup> without producing undue depression of the respiratory center. Severe respiratory depression interferes with adequate intake and elimination of the anesthetic agent. As a result, the load of detoxification on the body is increased with prolongation of the postoperative recovery period. Reflex irritability is related to the metabolic rate in that it represents the readiness to respond to stimuli. Age is a factor in metabolism. After adolescence, as the age of an individual increases, the metabolic rate diminishes. Common factors which tend to elevate metabolic rate and increase reflex irritability are pain, fear, fever and endocrine overactivity. Notoriously resistant to anesthesia are individuals of the muscular, pyknic type, alcoholics and patients taking drugs (thyroid extract). Factors that reduce metabolism and reflex irritability are found in hypothyroid states, cachexia, aged individuals and shock.

Preliminary medication is best administered by the use of a combination of drugs. Adequate rest during the night preceding the operation is a necessity. A short acting barbiturate, such as nembutal or seconal, in moderate dosage will usually meet this requirement. No food or fluids are given after midnight.

Since rises in metabolic rate tend to increase resistance to anesthesia, drugs employed in premedication seek to counteract this elevation either by direct depression of metabolism or by correcting those factors effecting metabolism. The drug most commonly used for this purpose is morphine. On the morning of the operative day morphine is given subcutaneously. Its maximum analgesic effect is reached in about sixty to ninety minutes.<sup>3,4</sup> Hence, the optimum time for subcutaneous administration of morphine is one and a half hours prior to onset of anesthesia. In emergencies the intravenous route can be substituted with satisfactory results, taking two minutes for administration and using

the same dose as for the subcutaneous route. In fifteen or twenty minutes a desirable effect is obtained. If the patient is sensitive to morphine, pantapone or demerol may be substituted. Only condemnation can be expressed for the common practice of subcutaneous administration of pre-operative sedation as the patient is about to be brought to the operating room. The importance of correct timing of premedication lies in the more efficient course of the anesthesia. Disregarding of timing may result in a synergism of premedication with anesthetic depression.

A member of the belladonna group, such as scopolamine or atropine is given simultaneously with morphine by the same route. These drugs counteract the undesirable side effects of morphine, such as excessive respiratory secretions, respiratory depression, nausea and vomiting.<sup>4</sup> Scopolamine is more effective than atropine for these purposes in smaller doses and has the additional advantage of inducing psychic sedation amnesia.

When local anesthesia is employed, susceptible individuals may develop convulsions, circulatory collapse or respiratory failure. The neurologic manifestations may be avoided by preliminary medication with the barbiturates such as nembutal or seconal, given orally two hours prior to anesthesia.

With intravenous anesthesia preliminary sedation is not necessary but is advisable in light dosage. A member of the belladonna group will combat excess secretions of mucus in the respiratory tract.

#### STAGES OF ANESTHESIA

The gynecologist should also be acquainted with the various stages of anesthesia through which a patient passes in order to understand the scope and limitations of each phase.

Inhalation anesthesia is commonly divided into four stages: The first is the stage of *analgesia* wherein consciousness is not lost but pain perception is decreased.

Practical application is extended to vaginal examination in the apprehensive patient.

The second is that of *delirium* or excitement. This stage should be passed through as rapidly as possible in order to avoid serious deleterious effects on the patient. The patient may actually break restraints, leap off the table and injure herself. Ventricular fibrillation with sudden death has been known to occur. During this period full cooperation must be given the anesthesiologist by avoiding unnecessary handling and contacting (draping) the patient and by eliminating noises.

In the third stage, that of *surgical anesthesia*, consciousness has been abolished. It is divided into four planes depending upon the depth. In the first plane procedures are performed that require abolition of pain but no muscular relaxation. Here incision into abscess cavities, dilatation and curettage, colpotomy, biopsy and minor vaginal surgery can be done. At the start of the second plane sufficient muscular relaxation is present to permit perineorrhaphy. As a rule sufficient abdominal muscular relaxation is present to permit the greater portion of abdominal surgery. However, there are cases in which adequate abdominal muscular relaxation is not obtained and the patient must be carried into the third plane. Lower third and fourth planes of anesthesia are to be avoided because the increasing paralysis of the intercostal muscles allows uninhibited activity of the diaphragm, thus producing a jerky type of respiration that interferes with the work of the surgeon.

The fourth stage is the stage beginning with *respiratory paralysis* and ending with *circulatory failure*. The appearance of respiratory failure is no indication that the patient is dead. Resuscitation by artificial respiration with oxygen must be instituted together with prompt elimination of the anesthetic agent until spontaneous respiration is restored.

With the increasing complexity of the field of anesthesia, the surgeon cannot be expected to know which agent is best for

his patient. He has a right to adequate working conditions so that he can perform his part with ease and with as little trauma as possible. He can indicate to the anesthesiologist these working conditions, but the selection of the anesthetic is the province of the anesthesiologist. The latter's prime concern is the safety of the patient. He selects those agents which provide for safety not only during the operative procedure but also during the postoperative period. Comfort to the patient is provided after the considerations of safety and suitable working provisions for the surgeon are met. For example, the gynecologic surgeon who requests avertin administered in the patient's room preoperatively for a dilatation and curettage, does not realize that the prolonged postoperative depression for so short a procedure is unwarranted.

Although the selection of the anesthetic drugs in a given case is based upon the experience of the anesthesiologist, the gynecologic surgeon should have a general idea of those agents which can provide the most favorable working conditions.

#### CHOICE OF ANESTHESIA

The choice of an anesthetic agent is based upon the characteristics presented by the individual patient, regardless of whether she has co-existing normal or abnormal systems. For the patient about to undergo gynecologic surgery, having otherwise normal systems, the choice of an anesthetic agent will depend mainly upon the type of operative procedure. For operations of short duration any of the general inhalation agents, intravenous, anesthesia or regional blocks, may be used. If the patient is very high strung, regional anesthesia is not advised. For these individuals induction with pentothal may be used in order to avoid the excitement stage found with general inhalation agents. If cautery is necessary, pentothal, regional anesthesia or nitrous oxide would be most practical for the explosiveness of ether, cyclopropane and ethylene are imminent dangers.

For longer procedures an agent such as pentothal is not advised because it has a tendency to lose its properties of a rapid acting agent and to assume the characteristics of a longer acting barbiturate with resultant respiratory and circulatory complications during the period of post-anesthetic narcosis. Thus any of the inhalation agents or regional anesthesia, including spinal block, are most commonly used.

Another aspect that affects the choice of an anesthetic agent is the type of operative procedure. In general, gynecologic operations may be divided into vaginal or abdominal, or a combination of the two. In vaginal work muscular relaxation is not commonly required. Fistula repair and vaginal hysterectomy enter this category. In abdominal operations an added factor, that of abdominal wall relaxation, is necessary and may be accomplished by various agents. Ether or spinal anesthesia may produce excellent relaxation alone. Cyclopropane in some cases can produce fairly adequate relaxation especially in the non-obese individuals with lax abdominal walls. Since the introduction of curare it is now possible to obtain satisfactory relaxation with even such agents as nitrous oxide, ethylene, pentothal or cyclopropane.

Very often gynecologic operative procedures because of technical and pathologic reasons are of prolonged duration. At no time is handling of tissue sacrificed for speed. The factors of time and operative difficulties, nevertheless, tax the patient so as to require the utmost skill of the anesthesiologist to maintain physiologic processes as nearly close to normal as possible. This goal is best attained by (1) replacement of lost fluids, electrolytes and blood, (2) efficient absorption of carbon dioxide, (3) maintenance of an open airway best attained by use of an endotracheal tube and (4) adequate oxygen intake. In spite of all these precautions prolonged anesthesia may produce relaxation of the peripheral vascular tone and result in a gradual lowering of blood pressure with its possible shock component.

This undesired effect is best combated by parenteral fluids and blood, and keeping the anesthesia as light as possible. We suggest at the start of each operative procedure that intravenous fluids be administered, usually 5 per cent dextrose in distilled water or normal saline.

When intravenous fluids are given, the Well's arm protector permits the arm to rest along the body and out of the way of the surgeon. This brings the intravenous tubing closer to the anesthesiologist's hand and avoids the unfortunate complication of radial nerve palsy. The latter results when the patient is in Trendelenburg position with her arm outstretched to receive the intravenous fluids. The shoulder brace depresses the clavicle against the first rib and impinges upon the brachial plexus. Another palsy occasionally met with in gynecologic surgery may arise from the lithotomy position if care is not taken to guard against pressure by the stirrups upon the peroneal nerve. The leg posts should be medial to the legs.

Complications are also encountered because of the nature of the disorder. Large masses if decompressed or removed too rapidly may result in marked drop in blood pressure even to shock levels. As a rule, if the mass to be removed is extremely large, the Trendelenburg position should be delayed to avoid further pressure on the diaphragm. After the major portion of the mass is removed the head of the table is lowered. In ectopic pregnancies with hemorrhage the anesthesiologist is concerned about two conditions: (1) The oxygen carrying capacity is reduced and (2) the low level of the blood pressure necessitates administration of the anesthetic agent with care so as not to embarrass further the already depressed vital functions. Such individuals require increased amounts of oxygen to combat the existing hypoxia and the anesthetic agent should be given in reduced quantities. Replacement therapy is of paramount importance and the surgeon must work rapidly and avoid unnecessary procedures and special technics.

Another condition in gynecology that must be carefully watched is the acute condition of the abdomen in which shock and toxemia are present. An example is a twisted ovarian cyst. In these patients the danger of acidosis from toxemia requires most careful supervision of the anesthetic system so as not to superimpose a respiratory acidosis upon the existing metabolic acidosis. Acidosis with anesthesia may precipitate the grave danger of convulsions and even death.

When patients present themselves with abnormal systems other than gynecologic, special anesthetic problems present themselves. Each patient is individually appraised in regard to the selection of the agent. There is no substitute for the anesthesiologist's knowledge of the pharmacologic and physiologic action of the agents he uses. The combination of pathologic disorders presented by patients are legion. To champion or condemn a given agent because of its theoretic effect on an abnormal system is hazardous. For example, cyclopropane, because of its effect upon the conduction mechanism of the heart, is not deemed advisable in the case of the cardiac patient. However, the advantages of quiet induction without the hazards of struggling, breath-holding and oxygen want make it an excellent agent for use in cardiac patients. In a patient with a large non-toxic thyroid causing deviation of the trachea spinal anesthesia would not be advisable were vagal reflexes to produce respiratory arrest. Artificial respiration without an endotracheal tube in place would be very difficult. Further, spinal anesthesia would be ordinarily advisable for upper respiratory infections. However, if the patient should be a hypertensive, blood pressure under spinal anesthesia might be extremely unstable.

These examples can be listed indefinitely to show that what would be a good technic in one patient would be contraindicated in another. There is no anesthetic of choice. It is not only the agent but also the administrator that make for the success

of the anesthesia. The surgeon can cooperate by discussing each case with the anesthesiologist.

The surgeon's understanding of the anesthetic considerations in cases in which a pathologic condition exists in systems other than gynecologic can do much to promote closer cooperation with the anesthesiologist. His interest goes beyond the recognition of the disorder. What he wishes to know is what anesthetic agent may be safely employed in the most commonly encountered pathologic conditions associated with gynecologic disturbances. In the order of frequency, in our experience, the following conditions are met:

1. In *obesity* the overweight places a strain upon the heart by increasing the resistance of the peripheral circulation. Fatty infiltration of the myocardium, in addition, decreases the effectiveness of cardiac work. Blood pressure is unstable. As a result, obese individuals tolerate spinal anesthesia poorly. Tissue saturation and desaturation are slow because of the poor blood supply to the tissues. Therefore, inhalation agents such as ether tend to result in slow inductions of anesthesia and prolonged postoperative recovery periods. Rapidly absorbed and eliminated agents such as cyclopropane, nitrous oxide and ethylene are preferable. Regional blocks other than spinal are valuable in extremes of obesity. Because of the relatively short, fat neck in the obese individual it is difficult to maintain an unobstructed airway. Endotracheal intubation is advisable in such cases.

2. *Anemias* are of concern in anesthetic procedures because of the reduced oxygen-carrying capacity of the blood. In chronic cases iron and blood transfusions should be administered during the preoperative preparation. In acute situations, such as in ruptured ectopic pregnancy or severe bleeding fibroids, blood must be given during the operation. Our experience reveals that blood transfusions given in all cases of anemia during the operation aids in rapid postoperative recovery. The anesthetic

agent chosen must permit the concurrent administration of adequate oxygen. Spinal anesthesia is not the method of choice. The hypoxia following possible fall in blood pressure superimposed upon an anemic anoxia may initiate irreversible neurologic damage.

3. *Hypertension* and *menopausal* vasomotor instability are frequently associated with gynecologic disturbance. The objective desired in the anesthetic management is avoidance of marked shifts in the blood pressure from the range normally maintained by the patient. Undue elevation of the pressure may result in cerebrovascular accidents. Precipitous drops in pressure may adversely affect the coronary and cerebral circulation. Inhalation anesthesia is the method of choice. Even cyclopropane may be used if due care is taken to avoid excess accumulation of carbon dioxide by depression of the tidal exchange. High spinal anesthesia is to be avoided because of the possibility of producing dangerous drops in blood pressure.

4. In *hypothyroid* states the resistance to depressant drugs is reduced because the metabolic rate is reduced. Any agent in decreased quantities can be used.

5. Many medical men do not realize the power of reassurance in combating the *apprehension* and anxiety states that most individuals feel prior to anesthesia and operation. In combination with proper premedication the average patient can arrive in the operating room in a suitable state of tranquility. Occasionally, one meets with patients who reveal a pathologic fear of the anticipated ordeal. The seasoned anesthesiologist regards them with utmost caution. There are few who have not experienced or heard of the patient who assured those about her that she would not recover from the anesthetic and actually did not. These deaths are believed due to excess secretion of adrenalin upon a heart sensitized by the anesthetic agent. Such patients are best put to sleep in their beds with pentothal or avertin before

taking them to the operating room. No forms of local and regional anesthesia are advised.

6. Compensated *cardiac* patients properly prepared preoperatively can tolerate most types of anesthesia given with proper amounts of oxygen and a patent airway. Excess falls in blood pressure are dangerous because of possibility of hypoxia of the myocardium. Elective operations should not be performed on these patients until the decompensation has been treated. In emergencies local anesthesia is the method of choice. Only minimal procedures should be performed.

7. With acute *respiratory infections* elective operations should not be done. In emergency cases local or low spinal anesthesia may be used. Patients with bronchitis and inveterate cigarette smokers are best operated upon under some form of local or regional anesthesia. If the patient must be asleep, cyclopropane can be used because of its relatively non-irritating effects on the respiratory mucosa. *Asthmatics* are best anesthetized with agents like ether, nitrous oxide, ethylene or regional anesthesia. Cyclopropane and pentothal constrict the bronchioles and further embarrass the asthmatic condition. Ether, if carefully given avoiding excess mucus secretion, can be used. Emphasis should be directed postoperatively on vigorous stir-up of these patients by insisting on coughing, frequent turning, voluntary hyperventilation and early ambulation.

8. In *diabetes mellitus* agents which unnecessarily disturb the acid-base balance of the body must be cautiously used. Provided other contraindications do not exist, choice may be best made from cyclopropane, nitrous oxide, ethylene and regional anesthesia. Control of diabetes before and during surgery is of extreme importance.

9. *Aged patients* in whom a minimal of degenerative conditions is found represent a group in which the metabolic rate is decreased. The anesthetic management is like that for hypothyroid individuals. Agents,

such as avertin, pentothal and ether must be used cautiously in order to avoid prolonged postoperative narcosis with the danger of atelectasis and hypostatic pneumonia.

10. *Nephritis*, unassociated with overt cardiac disturbance, necessitates the use of agents which do not depend primarily on the kidney for excretion. Avertin which is conjugated in the liver and eliminated by the kidneys can produce undue postoperative depression. Opiates should be prescribed in minimal dosage. In nephritis with hypertension the considerations discussed under hypertension should be observed. In acute and subacute glomerulonephritis cyclopropane is usually used. Minimal disturbance in acid-base balance and kidney parenchyma is thus attained.

11. When extensive fibrotic infiltration of pulmonary parenchyma exists following inactivation of *tuberculosis*, the use of inhalation agents would result in slow induction and recovery of anesthesia. Pentothal, by virtue of its depression of respiration, should be used in minimal amounts with nitrous oxide and oxygen in order to avoid oxygen want. If the healed tuberculous lesion is small, most methods of anesthesia can be used. In active pulmonary tuberculosis agents which are non-irritating to the pulmonary tissues and can be used with adequate oxygen are indicated. Cyclopropane and regional anesthesia are favored.

12. Occasionally the *uncontrolled toxic thyroid* patient comes to operation because of an acute gynecologic condition such as bleeding extopic pregnancy or twisted ovarian cyst. The combination of these two pathologic conditions demand rapid operative intervention and the use of ample oxygen. Pentothal should be started while the patient is in her room, care being taken that the dosage is small. The shock component with its depression of vital functions may counterbalance the high metabolic rate and its increased reflex irritability in such a patient.

13. *Syphilis* may be mentioned to stress the importance of recognition of aortic

insufficiency. Electocardiogram and chest x-ray should be done routinely to aid the physical diagnosis. If insufficiency is present, the large pulse pressure warns against the use of spinal anesthesia. A drop in blood pressure from such an anesthesia would be disastrous. Further, the medico-legal consequences from possible potential added or exacerbated cord disturbance are practical contraindications for spinals in these patients. Often after the laparotomy packs are removed, the surgeon is the first to notice a dilated stomach. The anesthesiologist should be informed about such a condition. Interference with respiratory movement by pressure on the diaphragm and the undesirable reflex effects on the heart and circulatory system can then be relieved by the use of a stomach tube.

The interest in the anesthetic course does not terminate with the conclusion of the anesthetic. When the patient has had a general anesthetic, she should be watched until reflexes have returned. Too often the patient left alone may develop respiratory obstruction due to relaxation of the tongue which may result in fatal asphyxiation. Until the patient awakens the nurse should turn the patient at frequent intervals and stimulate deep breathing by periodic carbon dioxide inhalations. After all types of anesthesia as soon as sensation or consciousness has returned, the patient should be encouraged to turn or be turned frequently, to cough and hyperventilate herself voluntarily. When patients refuse to cooperate, hyperventilation may be induced with periodic inhalations of carbon dioxide. If this "stir-up" regimen is neglected, post-anesthetic depression of respiration may result in atelectasis. Once atelectasis develops it may be necessary to remove the causative bronchial plug by aspiration through an endotracheal tube or a bronchoscope. Early movement and ambulation of the patient has also aided in preventing other complications resulting from circulatory stagnation, pressure and diminished physiologic activity.



## CONCLUSIONS

1. The operating gynecologist and the anesthesiologist in close cooperation can give the patient the proper and safe anesthetic.
2. There must not be any self-styled dogmas in anesthesiology.
3. The anesthetic agent must be selected for each case individually and the patient is not to be fitted to a given anesthetic. There is no "anesthetic of choice."

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PRESACRAL neurectomy is not helpful for all types of dysmenorrhea. The results are often unsatisfactory in secondary congestive cases. However, excellent results (75 per cent to 100 per cent of cures) are obtainable when this operation is done for patients having the primary spasmodic type of dysmenorrhea, especially those on whom all other previously tried minor procedures, namely, cervical dilatation, exercises, alcohol injections of the pelvic plexus, etc., have been of no avail. (*Richard A. Leonardo, M.D.*)

# HYSTERECTOMY\*

## A STUDY OF TYPES, POINTS OF TECHNIC AND CONCLUSIONS

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**A**N analysis of all hysterectomies performed on the author's service from March 10, 1946, to March 10, 1948 is herewith presented. There have been 161 hysterectomies done by six operators during this two-year period. Many articles have been written on this subject but the writer believes that certain phases can be repeated for emphasis while others may be brought to the front. This article deals primarily with the routine as carried out plus an attempt toward an honest appraisal of that routine.

### GENERAL CONSIDERATIONS

The decision of whether or not to perform a hysterectomy is often a difficult problem and many factors must be considered before reaching a decision. There are two important factors which must be accepted before arriving at a decision: (1) The psychologic effect on the patient; usually the younger the patient, the greater the psychic trauma. Steps should always be taken to minimize this trauma. (2) The menopause will occur at an earlier age, and the younger the patient when the hysterectomy is performed the younger she will be at her menopause.

Experience has taught this writer that certain general principles should be followed when possible:

1. The uterus should never be left intact when both ovaries have been removed. Uterine bleeding often occurs and will continue in spite of all measures to control it unless another operation is performed to remove the uterus. Also, a "dead organ" is left which may be the future source of

carcinoma and it serves no useful purpose. Therefore, many hysterectomies were done for adnexal disease rather than uterine disease.

2. In women who are forty years old or older with a prolapse requiring surgery a hysterectomy should be done, with few exceptions, plus repair of the pelvic structures.

3. Serious consideration should be given to removal of the ovaries, as well as the uterus, in all women with symptoms of menopause, and in those forty-five years or older even though they appear normal at the time. Needless to say, these organs always should be removed if there is a question of malignancy.

Therefore, a normal uterus will be removed for: (1) Malignancy of the ovaries, (2) tuberculous salpingitis, (3) certain cases of prolapse, especially in women forty years of age or older, (4) severe and uncontrollable bleeding at or near the menopause, (5) inflammatory conditions requiring removal of the ovaries and (6) other conditions which require removal of the second ovary. Also, normal ovaries will be removed for: (1) Cervical and fundal malignancies and (2) benign conditions requiring hysterectomy in women at or near the menopause.

### TYPES OF HYSTERECTOMY

*Supracervical.* As improvements in technic are evolved and antibiotics are used more and more indications for supracervical hysterectomy become harder to justify. Transfusions, also, have further narrowed the indications for this procedure. Briefly, during this period the supracervical

\* Data from the Obstetrical and Gynecological Service of the U. S. Naval Hospital, Bethesda, Md. The opinions and/or assertions contained herein are the private ones of the writer, and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

procedure was done only in nulliparous women who had a healthy cervix without a history of leukorrhea or previous trouble with the cervix. Furthermore, it was done only for benign conditions.

Partial hysterectomy was done twenty-one times for fibroids, twice for severe menorrhagia with one removed ovary and the other cystic, three times for menorrhagia with both ovaries already removed, once for severe menopausal bleeding, five times for a frozen pelvis from an inflammatory condition of long-standing and twice for postabortal pelvic abscesses.

*Total Abdominal.* Indications for total hysterectomy probably could best be summarized with the words that it should be done in all cases in which hysterectomy is indicated. Prevention of carcinoma in the remaining cervix is sufficient reason for doing a total hysterectomy in benignancy as long as the operation does not introduce an element of extra danger to the patient.

*Total Vaginal.* In this series all vaginal hysterectomies were of the total type and were associated with vaginal repair. The limitations and advantages of this procedure are too well known to warrant discussion. Vaginal hysterectomy was done twice for fibroids and associated cystocele and rectocele, once for menorrhagia of the menopause associated with a prolapse of the uterus, seven times for third degree prolapse of the uterus and once for hypertrophy of the cervix and acute cervicitis.

*Radical Hysterectomy.* Radical hysterectomy has been used only for cervical carcinoma and it was done twice for each of stages I, II and III (as outlined in a report of the League of Nations). The type of procedure has been more radical than that advocated by Wertheim and really was of the Latzko type. All procedures were preceded by irradiation with 4,000 mg. hours of radium used interstitially, as well as in tandem, in the cervical canal. There have been three stage IV cervical carcinomas which have been considered inoperable. It will be noted that this procedure has not been used for carcinoma *in situ* (intra-

epithelial carcinoma) but rather a "wide" total hysterectomy, bilateral oophorectomy and salpingectomy have been done. Follow-ups for a longer period of time may indicate the radical procedure for these lesions also.

#### PREOPERATIVE PREPARATION AND POSTOPERATIVE CARE

As with any other type of operation the patients were given a thorough physical examination, including complete blood counts, urinalyses and any other examination indicated. Good sedation the night before was given to insure a full night's rest. The day before surgery the patient was given 2,000 cc. of high caloric liquids in addition to a regular, high protein diet. Enemas were seldom used as they seemed to irritate the bowel and result in greater distention. The morning of surgery the patient was sedated well with nembutal, scopolamine and morphine. Vaginal douching has not been used by this writer for many years.

Those patients being operated upon for malignancy have a urologic study, proctoscopic examination, chest and bone x-ray survey before operation; distant metastasis was a contraindication to surgery. In cases of fundal carcinoma the cervix was sutured closed before the abdomen was opened. With the simplest of patients excepted, all were typed and cross-matched preoperatively.

Patients with carcinoma, except carcinoma *in situ*, were irradiated preoperatively. The patient was then checked every two weeks until the maximum reaction began to subside. This has varied from six to ten weeks.

Those patients who were to undergo the radical type of operation had catheters placed in their ureters shortly before surgery and they were left in place following surgery for forty-eight hours or longer if the urine continued to show blood. It has been thought that the splinting action of the catheters postoperatively helps prevent ureteral complications.

The anesthesia for these patients was spinal, with gas-ether in those with some contraindication to a spinal, usually hypertension. Continuous spinal was used for all the radical operations in this series. Blood was given continuously during the radical procedure and the speed varied to keep the patient's condition satisfactory. Blood was always available for other patients who were likely to need it.

Postoperative care was usually routine with the following possible exceptions: (1) Oxygen was used freely to combat distention, especially in the radical patients. (2) All patients were encouraged to eat as soon as they tolerated food and as nearly a regular diet as possible. (3) If the patients did not tolerate foods and fluids after the first day or two, they were given intravenous proteins, glucose and saline in proportion to maintain electrolytic balance. (4) Penicillin was given in doses of 60 to 100 thousand unit doses every three hours in all those with radical cases and in 81 per cent of those remaining with total hysterectomies. This was continued for forty doses or five days unless indicated for a longer period. (5) Patients were encouraged to get out of bed on the second or third day.

#### TECHNIC

*Supracervical.* The essential variation from the routine was the round ligaments were ligated near the lateral wall and were not used to suture to the cervical stump. This procedure eliminates the pain from pull on the round ligaments, and since the normal supports are not disturbed in supracervical hysterectomy, the round ligaments are not needed for that purpose.

*Total Abdominal.* The following variations have been found very useful: (1) The round ligaments were cut near the lateral wall; (2) the pubocervical fascia was detached from the cervix and pushed downward; (3) a single suture was passed around the cardinal and uterosacral ligaments on each side and then they were detached.

This procedure minimizes hemorrhage greatly, as well as allowing the upper end of the vagina to come up higher from the pelvis, making removal of the cervix from the vagina much easier; (4) the pubocervical fascia, the cardinal ligament and the uterosacral ligament all were sutured to the angle of the vagina by a single, special suture on either side; (5) no further sutures were used in the vaginal cuff; (6) a tape drain, doubled, was placed through the cuff into the vagina in order to drain the subperitoneal space when the reflection of the bladder peritoneum was closed to the posterior peritoneum; (7) when the vagina was opened, it was held high in the pelvis while one or two 4 by 4 gauze "flats" were pushed into the vagina to prevent spillage, an abdominal pack having been placed in the cul-de-sac previously.

*Total Vaginal.* Vaginal hysterectomy was usually conventional except for the following: (1) The anterior vaginal wall was opened and the bladder freely mobilized before proceeding with the hysterectomy; (2) the pubocervical fascia, cardinal ligaments and uterosacral ligaments were anchored at the angles of the vagina as just described; (3) the peritoneum was then closed completely and a drain left in the vagina with the cuff left open; (4) cystocele repair was done; (5) the posterior vaginal repair was done next, taking care to unite the uterosacral ligaments together throughout their length to insure against enterocele which occasionally occurs with the usual procedures. Pryor clamps were not used for any patients in this series.

*Radical Type.* Special points in this procedure were: (1) Catheterization of the ureters leaving the catheters in place as noted earlier; (2) care was taken to preserve the ureteral blood supply; (3) more radical removal of the glands and cul-de-sac peritoneum was done than in the classical Wertheim procedure; (4) no attempt was made to close the vagina but gauze or oxycel was used from the defect through the vagina to control oozing and promote free drainage.

## CLINICAL COURSE

*Supracervical.* From Table I one may get a pictorial view of the clinical course. During operation there was one ureter cut but it was repaired and the follow-ups for some two years have shown no evidence

of severe penicillin urticarial reaction; one patient had a severe concurrent bronchiectasis; there was one pelvic abscess and one patient showed partial intestinal obstruction on the seventh postoperative day which was relieved by conservative meas-

TABLE I  
SUMMARY OF CLINICAL FINDINGS

Type Operation	Total Cases	Age	Opera-tors	Trans-fusions	Plasma Alone	Post-operative Catheter-ization	Short Vagina	Vault Granu-lations	Morbidity	Para o	1	2	3	4	5	6	7
Radical...	6	27-53 38	1	6 100%	0 ..	6 100%	6 100%	3 50%	5 83.3%	1	..	..	4	1	..	..	..
Total.....	110	21-53 41.5 22-48	4	17 15.45%	3 2.7%	34 30.9%	1 0.9%	31 28.2%	15 13.6%	21	38	22	18	7	1	2	1
Subtotal...	34	31.8 34-53	4	4 11.76%	0 ..	12 35.3%	0 ..	.. ..	5 14.7%	31	1	1	1	..	..	..	..
Vaginal....	11	42	2	2 18.2%	0 ..	11 100%	0 ..	3 27.2%	5 45.4%	..	..	5	4	1	1	..	..

of stricture. There was one patient who had a concurrent acid-fast infection of a main bronchus. After her recovery from the hysterectomy a pneumonectomy was done. She is doing quite well fifteen months following the latter procedure. Four patients, or 11.76 per cent, received transfusions during or immediately following surgery. Postoperative catheterization was necessary in 35.5 per cent. There was morbidity in 14.7 per cent of these patients, consisting of a temperature of 100.4°F. or above on any two consecutive days, including the day of operation. This same criteria was used for morbidity in all cases of hysterectomy.

*Total Abdominal.* The complications in this group proved more annoying than serious. There were some seven cases which caused concern. One patient went into shock from acute gastric distention; there was one case of severe shock, apparently postanesthetic, as there was no hemorrhage and one case of acute upper respiratory infection; one patient had a severe chill on the third postoperative day and the cause was never determined; there was one case

of stricture. There were 15.45 per cent of these patients who received transfusions during, or soon after surgery and 2.72 per cent received plasma. There were 30.9 per cent of these patients who required postoperative catheterization. There was shortening of the vagina in one subject which interfered with vaginal function. At the six-weeks check-up there were vault granulations in 28.2 per cent, all of which cleared with one application of 20 per cent silver nitrate. Morbidity was present in 13.63 per cent of these cases.

*Vaginal.* Cystitis of a mild degree was present in all these cases following either repeated catheterization or a retention catheter. Both methods were used and with comparable reactions in the patient. There were two cases of severe, acute cystitis. Had a vaginoplastic procedure not been done in these cases, cystitis would surely have been less of a problem. There were 18.2 per cent who received transfusions and none were given plasma. There were vault granulations at six weeks in 27.2 per cent of the patients, and in all but one the condition cleared with one applica-

tion of silver nitrate while that one cleared following the second application. Morbidity was recorded in 45.5 per cent of these patients in spite of the fact that their general well being was better than in those in the group of abdominal totals. There was one patient found to have an enterocele of a mild degree one year following surgery. This has not necessitated repair and does not seem to be progressing. One subject developed severe sciatica on the right side which subsided in about three weeks.

*Radical.* Strange as it may seem, this is the only group showing no complications other than morbidity. However, such a small number of cases is of no statistical value; furthermore, preoperative preparation, blood during surgery, etc., made these patients as nearly an ideal risk as possible. There were no fistulas or pelvic abscesses. All these patients are living and have shown no evidence of recurrence although it is too soon for this fact to mean much.

#### CONCLUSIONS

When complications and morbidity are taken into account, there seems to be practically no justification for supracervical hysterectomy except in training younger men and then only in nulliparous women who have no history or findings suggestive of cervical infection.

The uterus should always be removed when the ovaries are removed. Therefore, many hysterectomies should be done for adnexal disease rather than uterine disease. Women who are forty years of age or more, with a prolapse requiring surgery in general, should have vaginal hysterectomy plus vaginoplasty. In women near the menopause or older serious consideration should always be given to removal of the ovaries.

Radical hysterectomy is recommended in all stages (I and II) and certain stage-III cases of epidermoid carcinoma of the cervix as well as some cases of adenocarcinoma of the fundus all following radium irradiation. Irradiation does not seem to destroy ma-

lignancy in the lymph glands. It has not been deemed advisable to do radical surgery for carcinoma *in situ*. Ureteral catheters were used in all these cases during and following surgery.

The better the preoperative and postoperative care the quicker will be the recovery of the patient. Early rising definitely seems to aid recovery and there were no cases of thrombophlebitis or phlebothrombosis diagnosed in any case postoperatively. It would seem that penicillin postoperatively in 60 to 100 thousand unit doses every three hours for forty doses is of definite value.

Support of the vagina and cervix should come from proper attention to the uterosacral and cardinal ligaments and pubocervical fascia; the round ligaments should be left unattached. Leaving the vaginal cuff open seems to be most beneficial and healing occurs as rapidly as when it is closed. Granulations in the cuff at six weeks are no more frequent in these cases. When a vaginal hysterectomy is done, the uterosacral ligaments should be approximated around the rectum and forward to the vagina to prevent enterocele at a later date.

It is interesting to note that the average temperature curve was normal in all groups by the seventh postoperative day and that the highest composite curves were normal only a day later. Therefore, morbidity *per se* seems to be of little or no significance and when unassociated with other conditions should cause no great concern. Morbidity was essentially the same in total and subtotal groups. There is more blood loss in the vaginal, the total, (abdominal) and supracervical, in order, as indicated by transfusions needed. The radical, of course, always necessitates transfusion for the best interest of the patient. Postoperative catheterizations were 35.3 per cent in the subtotal group as compared with 30.9 per cent in the total group.

Shortening of the vagina occurs in fully 50 per cent of the radical cases sufficient to interfere with its function but was a problem in only one other case.

If one groups some of these cases under the principal indication, one will find that seventy-two cases, or 44.5 per cent, were of fibroid tumors; twenty-seven cases, or 16.8 per cent, were of inflammatory conditions; twenty-four cases, or 14.9 per cent, of menorrhagia; twelve cases, or 7.4 per cent, of uterine malignancy; five cases, or

3.1 per cent, of ovarian tumors, four of which were malignant; therefore, 10 per cent of the hysterectomies were done for malignancies. The remaining twenty-one cases, or approximately 13 per cent, were of miscellaneous conditions.

The associated operative procedures carried out may be seen in Table II. There were no deaths in this group of patients.

TABLE II  
OPERATIVE PROCEDURES

Procedures	Partial	Total	Vaginal	Radical	Total
Both ovaries, tubes and uterus.....	7	60	..	..	67
Both ovaries, tubes, appendix and uterus.....	2	7	..	..	9
One ovary, tube, appendix and uterus.....	1	8	..	..	9
Uterus alone.....	16	13	..	..	29
Uterus and appendix only.....	7	11	..	..	18
One ovary and uterus.....	1	..	..	..	1
One ovary, tube and uterus.....	..	11	..	..	11
Uterus plus anterior and posterior repair.....	..	..	11	..	11
Ovaries, tubes, glands, fat, etc.....	..	..	..	3	3
Ovaries, tubes, glands, fat and appendix.....	..	..	..	3	3
Total .....	..	..	..	..	161

#### SUMMARY

1. The 161 hysterectomies done on the author's service from March 10, 1946, to March 10, 1948 are analyzed.

2. Important factors pertaining to the decision of the type operation and some general principles to be followed are discussed.

3. Special points of technic are brought out.

4. Associated operative procedures and summary of clinical findings are diagrammatically illustrated in Table I and II.

5. Various conclusions are discussed.



# EXTRAPLEURAL PNEUMONOLYSIS WITH PLOMBAGE\*

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THE term "extrapleural pneumonolysis" implies freeing of the lung by establishment of a cleavage plane between the parietal pleura and the endothoracic fascia in order to obtain an effective as well as selective collapse of an area of circumscribed tuberculosis in the apex of the lung. As a result of such pleurolysis an extrapleural space is created which demands the insertion of some extraneous material for maintenance of the pulmonary collapse so produced.

The search for an optimum filling made this type of pneumonolysis one of the most interesting of all thoracic surgical procedures. From the time of the introduction of this form of collapse therapy by Tuffier<sup>1</sup> in 1891 many kinds of "plombe" materials appeared which, at the time of their introduction, were thought to represent the ideal extraneous material for maintenance of the extrapleural space. In each case, however, the new burst of enthusiasm was short-lived and the popularity of the procedure would decline until the introduction of a new filling material would lead to its revival.

In a discussion before the Medical Society of Magdeburg, Scherer<sup>2</sup> stated that Hippocrates had inserted a pig's bladder into a thoracotomy opening and inflated it. No mention was made as to the purpose of this maneuver but we might well cite it as one of our earliest plombages. We have mentioned Tuffier's case in 1891<sup>1</sup> at which time he separated the parietal pleura from the thoracic cage as a means of gaining surgical access to the apex of the lung. This probably represents the first successful resection for chronic phthisis. His pa-

tient was alive and well seven years after this procedure. In 1893, Tuffier again performed extrapleural pneumonolysis to control hemoptysis in a person suffering from chronic pulmonary tuberculosis. No tamponade or plombe material was employed here but the hemorrhage subsequently ceased. In 1910, this operator again employed this procedure and used a fat as a permanent filling material. In the years following he tried other filling materials which included omentum, fresh lipoma and in 1913 employed air for maintenance of the extrapleural space.

In the same year Mayer<sup>3</sup> also used nitrogen gas to maintain the extrapleural space and this probably represents the first use of extrapleural pneumothorax. Sarfert<sup>4</sup> in 1901 performed an extrapleural pneumonolysis preliminary to cavity drainage and inserted a gauze pack in the extrapleural space. His object was to produce a pleural symphysis so that the cavity could be opened at a later date without infecting the pleural space. Schlange<sup>5</sup> in 1907 performed extrapleural pneumonolysis using a gauze pack for compression of a tuberculous lung and this represents the first gauze tamponade employed for the actual compression of a tuberculous cavitory lesion.

The next great stride in the progress of extrapleural pneumonolysis came in 1913 when Baer<sup>6,7</sup> introduced his paraffin-bismuth-vioform mixture. This mixture, after proper sterilization, was kept at a temperature of 35°C. and was kneaded into pieces "the size of a pigeon's egg" and inserted into the extrapleural space until it was filled and the desired amount of pulmonary collapse produced. Jessen<sup>8</sup> in

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1921 reported use of a wax mixture but claimed that it had no advantage over the paraffin mixture advocated by Baer. Mayer<sup>3</sup> in 1913 performed pneumonolysis but inserted no extraneous filling material for the first four weeks. At the end of that time he inserted nitrogen gas into the space for maintenance of collapse and considered this the only satisfactory method of performing this procedure. Wilms<sup>9</sup> and Sauerbruch<sup>10</sup> in 1914 and Jessen<sup>8</sup> in 1921 mentioned Gewerder's use of a colpeurynter (a dilatable bag employed to distend the vagina) to maintain collapse after extrapleural pneumonolysis. Later in 1923, Rivière and Romanis<sup>11</sup> used a rubber balloon for this purpose.

Archibald<sup>12</sup> in 1921 was the first to employ a living filling material of pedicled muscle in the extrapleural space. His original idea was "... after separating the apex and bringing it down, to bring a flap from the pectoralis major muscle in front, and the trapezius or perhaps the rhomboid from behind, and to unite those flaps over the apex and under the clavicle and first rib, so as to form a sort of stirrup, as well as a simple mass of muscle, which would probably maintain compression permanently both by its mere bulk and also possibly through actual tonic contraction of the muscle fibers." Later, however, he believed that this procedure was too extensive and performed the procedure through an anterior approach using the pectoralis major and minor muscles to fill the extrapleural space. He also advocated combining this operation with a posterior columnar resection in certain cases.

Although Archibald is credited with having been the first to employ pedicled muscle to fill the extrapleural space, Wilms<sup>9</sup> in 1914 mentioned that one of his colleagues experimented with implantation of muscle in this space. He stated that in experimental animals the muscle substance would sink and a matted connective tissue meshwork would form. Although this operator did not seem too enthusiastic about muscle as a filling material, he did mention that

such a matted connective tissue framework would permit the entry of compressing substances, such as paraffin. This procedure had not been employed in human subjects at that time. Wilms also used fat in the extrapleural space but included the resected ribs between the parietal pleura and the fatty filling material, maintaining that more compression was obtained in this manner.

Lilienthal<sup>13,14</sup> in 1928 employed a crumpled rubber dam in the extrapleural space to obtain collapse. His idea was to force the rubber dam into this space under considerable pressure and employ a flat piece of gauze to hold it in place. The skin was then sutured over this filling. Four days later the sutures were removed and the dam and gauze taken out. Subsequent packings consisted of ordinary gauze packs to be replaced every three days. Lilienthal claimed that expansion of the rubber dam during the period in which it remained *in situ* rendered the extrapleural cavity larger than it was previously. He asserted that the space is often enlarged from double to treble the size present at the end of the operation. This operator also mentioned the use of pedicled breast as a living extrapleural pack in female patients. DeWinter and Sebrechts<sup>15</sup> also cited use of the mammary gland in those cases in which a large mass of filling material is needed. Sauerbruch<sup>16</sup> in 1920 reported the use of gelatin as a filling material. Other extraneous materials were employed by the Sauerbruch Clinic, as cited by Schulze,<sup>17</sup> which included such substances as silk, drawing crayons, lead bullets and rubber sponges. Schulze also cited Saidman as using a rubber sponge to maintain the extrapleural collapse and Lilienthal<sup>13</sup> also referred to its use. Schulze worked with natural sponge, which had been treated with a tannic acid mixture, and found that in experimental animals this represented an ideal filling material. Numerous microscopic sections illustrate this article and show how the sponge became infiltrated with connective tissue and Schulze was certainly enthusiastic over the

procedure at that time. However, no further account of its use in human subjects was to be found in the literature. Alexander<sup>18</sup> mentions the use of fibroid tumors and meshes of silver wire in the extrapleural space but no reference is made to the early authors who tried these two substances.

Matson<sup>34</sup> reported use of a combination of flexi-tissue and gauze packed into this lined space. When the space was filled, the flexi-tissue was tied off and the wound closed, thus leaving a flexi-tissue bag filled with gauze as a pack. This pack could be left *in situ* for a period of from two to three years provided no complicating factors arose. In 1930, Heine<sup>18,24,25</sup> of Brauer's Clinic announced the substance, vivocall, which consisted of beef serum which had been activated by calcium salts. He affirmed that when this substance was inserted in the extrapleural space it organized and became rubbery in consistency. Absolutely no irritation was supposed to be caused by its use. Prior to this Eden<sup>18</sup> in 1921 had used a liquefied human fat which he termed, humanol. He claimed that this substance was not absorbed and in time was converted into a fat-like mass, thus offering what in all probability would be the ideal filling. Neither of these substances enjoyed much popularity and no mention of their use, except from a historical standpoint, is made in the recent literature.

As to extrapleural pneumothorax we have mentioned its use in 1913 by both Tuffier<sup>19</sup> and Mayer.<sup>3</sup> At this time Mayer was against all other forms of extrapleural packs when nitrogen gas could be employed, and it is interesting to note that many articles appear in recent literature advocating this procedure, singly or with oil as a supplement, in selective cases in which thoracoplasty is contraindicated.<sup>11,20,21</sup>

The first use of oil dates back to Hippocrates who is said to have injected warm oil into empyema cavities (Chandler and Gloyne).<sup>18</sup> In 1915, Burnand<sup>18</sup> used oil containing gomenol in a pyothorax and since that time it has been used for the various

pleuritides and to maintain collapse when obliterative phenomena endangered a successful pneumothorax. In a similar fashion oil was employed in the extrapleural space when this space was obliterating during extrapleural pneumothorax, and many recent operators<sup>20-23</sup> have advocated its routine use to prevent this latter complication. Either olive oil or mineral oil is used with the addition of from 3 to 5 per cent gomenol.

Finally, in 1946, Wilson<sup>31,32</sup> reported his experience with methyl methacrylate, an acrylic resin with the trade name of lucite, as an extrapleural filling material and discovered that this substance produced almost no inflammatory reaction when placed in the pleural space in experimental animals.<sup>31</sup> Later he used this material in the extrapleural space in human subjects for the collapse of pulmonary tuberculous lesions<sup>32</sup> and again its non-irritating qualities were substantiated. With this finding by Wilson what promised to be the optimum extrapleural filling material received widespread recognition, and it is the results of our use of this type of filling material that we should like to evaluate in this paper.

#### ADVANTAGES AND DISADVANTAGES OF VARIOUS EXTRAPLEURAL PACKS AND METHODS OF TAMPONADE

In the preceding paragraphs twenty-nine different filling materials were mentioned and, although the reasons for failure of many of them are evident, we should like to discuss the advantages and disadvantages of those substances that enjoyed popular usage during the past half-century. In the case of fatty tissue it was found by some workers<sup>17,26</sup> to shrink too much to be effective. Baer,<sup>6</sup> Schulze<sup>17</sup> and Brunner<sup>26</sup> claimed that fat was resorbed by the body, but Wilms<sup>9</sup> asserted that it was not resorbed as readily as Baer maintained and offered several autoptic examples to substantiate his point. Archibald<sup>12</sup> and Davis<sup>27</sup> stated that fat probably undergoes at least partial liquefaction with consequent dimi-

nution in size and compression value. Archibald also pointed out the well known fact that fatty tissue was non-resistant to infection, especially after having been detached from its blood supply, and that many infections occurred following its use. Rivi re and Romanis<sup>11</sup> and Nissen<sup>28</sup> stated that many tuberculous patients were emaciated and that it was difficult to obtain fat from this type of patient. Nissen also offered the suggestion that fat was not satisfactory because of its inability to resist pressure exerted on the rigid cavity wall and hence, closure of the cavity was impossible in many such cases.

In paraffin pneumonolysis one of the principal causes of failure was infection with extrusion of the paraffin from the wound.<sup>3,12</sup> In addition, rupture into a cavity or bronchus<sup>10,25,26</sup> was common and many patients returned to the clinics expectorating small sausage-like particles of paraffin years after the procedure had been performed. If rupture into the cavity occurred at an early date or shortly after operation, an empyema of the extrapleural space with subsequent extrusion of the pack usually resulted. Sattler<sup>24</sup> mentioned a rupture of the pack into the pleural space and agreed that many such cases led to empyema with fatal termination. Archibald<sup>12</sup> and Brunner<sup>26</sup> persist in their belief that paraffin is a foreign body and that the introduction of any such substance into the human body will sooner or later bring disaster. Bruns and Casper<sup>29</sup> concur with these latter workers and state that when such a pack is introduced it will have to be removed. In 1913, Mayer<sup>3</sup> stated that he had used paraffin only in experimental animals and that in one instance gangrene of the lung resulted.

As for pedicled muscle Rivi re and Romanis<sup>11</sup> claim that a pack with pedicled muscle is not large enough and that many tuberculous patients are so emaciated that they have too little muscle to be used as a pack. DeWinter and Sebrechts<sup>15</sup> disagree with these authors on this particular point and believe that pedicled muscle is the

optimum pack. They agree that some fibrous shrinkage and atrophy occur in muscle tissue, a point of disadvantage mentioned by Rivi re and Romanis,<sup>11</sup> Lilienthal,<sup>13</sup> Brunner<sup>26</sup> and Bull,<sup>30</sup> but state that this atrophy is never more than one-third the original size, thus leaving a portion large enough to secure optimum collapse. Others maintain that a muscle pack is not good in the liquid milieu that inevitably forms in the extrapleural space, but again DeWinter and Sebrechts<sup>15</sup> disagree and join Archibald<sup>12</sup> in calling attention to the well known resistance of muscle to infection. They also point out that impairment of function in the arms or shoulders does not occur following detachment of the pectoralis major and minor muscles, as reported by numerous writers antagonistic to this type of filling material.

In the use of such substances as rubber sponge, silk and natural sponge it takes no stretch of the imagination to see why these were unsatisfactory as extrapleural packs. In the case of gauze and crumpled rubber dam tamponade the infected wound that resulted, plus the early obliteration of the space with marked loss of compression of the underlying collapsed lung, should also be evident. In the case of the colpeurynter and rubber balloon employed in the space a two-fold disadvantage existed: First, rubber is a marked tissue irritant and its mere presence in the tissues would lead to infection. Second, in both instances a tube had to connect with the outside from these objects in order to replace the air that inevitably leaked out. Such a communication invariably led to infection and empyema of the extrapleural space. In the case of the pedicled mammary gland, fibrous shrinkage and atrophy were great and the compression value of such a substance was limited. Sauerbruch's gelatin was obviously unsatisfactory because of its known liquefaction at body temperature with subsequent and almost immediate absorption.

In mentioning lipomas or fibroids for use in the extrapleural space we are certain that insertion of any type of neoplastic

tissue into the human body is contraindicated, regardless of the results one would hope to achieve from the collapse so produced. As for omentum its compressing value would certainly be poor and its resorption most likely to occur.

Surgeons in the early thirties were very optimistic about the substance, vivocoll<sup>18,24,25</sup> but in the course of time it was found to act as a foreign substance in the body and was either extruded from the wound or was resorbed. Humanol<sup>18</sup> was introduced as the optimum filling material in the early twenties but its sudden disappearance from the literature shortly after its introduction marked its definite failure.

Extrapleural pneumothorax was shown to have many disadvantages by Aufses and Romanis and Sellors. The main objections were early obliteration of the extrapleural space and infection. These objections were overcome, to a certain extent, by conversion of the extrapleural pneumothorax into an extrapleural oleothorax in from three to four weeks after its institution. Proctor<sup>20</sup> employed such a conversion as a routine procedure in his series of cases, performing extrapleural pneumothorax first. He made the space larger than necessary and then let it close to the desired size before adding oil. This allowed the addition of oil in a space in which the exudate had had time to absorb. Dolley<sup>20</sup> approves of the early conversion of extrapleural pneumothorax to oleothorax and in a discussion of a paper presented by Proctor<sup>20</sup> states that one should convert to oleothorax as soon as one is assured that the space is well established, that the pleural leaves are well thickened and that the danger of cavity wall necrosis is past. O'Brien<sup>20</sup> on the other hand, is opposed to oleothorax, both extrapleural and intrapleural. He states that he has seen two patients drown in oil with intrapleural oleothorax and that pressure necrosis and amyloidosis are constantly a danger associated with its use.

In 1946, Wilson<sup>31,32</sup> presented his experimental work on methyl methacrylate and offered it as the probable ideal filling ma-

terial for the extrapleural space. Our department accepted this material with eagerness and by the fall of 1947 twenty-two patients had undergone the extrapleural operation receiving the lucite pack.

Although each patient was carefully selected with strict adherence to the indications formulated regarding this procedure, our late results were not gratifying.<sup>33</sup> Such complications as erosion of the pack into the mediastinum and cervical area were encountered. In three patients the pack eroded into the cavity area, producing broncho-extrapleural communications which necessitated removal of the pack by virtue of the resulting empyema. In one patient microscopic evidence of foreign body reaction was noted in the fibrous matrix surrounding the pack following its removal for failure of cavity closure.

Results in our series were poor and complications numerous. At present the procedure has been abandoned on the surgical service at Oteen and it is believed that most investigators working with lucite will ultimately abandon its use as an extrapleural pack. Lucite as employed in this procedure has not withstood the test of careful scientific investigation and may be listed as another failure in the search for the optimum filling material for maintenance of the extrapleural space.

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# Case Reports

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## SURGICAL TREATMENT OF CORROSIVE GASTRITIS\*

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IN reviewing American medical literature on the late gastric sequelae of corrosive poisoning it was found that only eleven cases have been reported.<sup>1-5</sup> The important findings and the treatment of corrosive gastritis were reviewed by Boikan and Singer<sup>4</sup> and Meyer and Steigmann.<sup>5</sup> Undoubtedly more cases exist than have been reported but since the condition is relatively rare it seemed desirable to review briefly the salient features in the treatment of such patients and to present two additional cases.

The stomach lesions which result are dependent on whether alkali or acid has been ingested and on the state of the stomach at the time the corrosive material was taken. Some of the patients who ingest a highly concentrated corrosive succumb early because of esophageal or gastric perforation. In others vomiting ceases, the oral lesions disappear and several days after first aid therapy has been rendered many of the patients appear well enough to be discharged.

After a lapse of from one to eight months the patient again seeks medical care because of vomiting, epigastric pain and emaciation. Achlorhydria is present and x-ray examination reveals an obstructive lesion in the upper gastrointestinal tract.

Since the location and character of the lesion is dependent on the type of corrosive material swallowed and the state of the stomach at the time, it is well to re-em-

phasize the following points: Lye involves all tissues equally but usually damages the stomach less than the esophagus because of dilution. Acids ordinarily have only a mild effect on the esophagus but produce more trouble in the stomach. Whether the stomach is empty or full at the time of ingestion is important. In a full stomach the corrosive agent passes along the lesser curvature to the pylorus, pylorospasm occurs and the corrosive agent is thus brought in contact with the distal portion of the stomach. In such a case damage at the pylorus and lesser curvature would be expected. In the empty stomach the corrosive fluid comes in diffuse contact with the gastric mucosa and most of the damage occurs at the pylorus and pars media.

Pyloric stenosis, tubular narrowing of the antrum and pylorus, hour-glass constriction and other deformities may result.

The late gastric sequelae are most often confused with gastric carcinoma. The main differentiating features are the history of corrosive ingestion and the absence of blood in the vomitus and stool. The history is of utmost importance in making an x-ray diagnosis since there are no definite criteria upon which an x-ray diagnosis of corrosive gastritis can be made.

The treatment of these patients is usually surgical. Medical treatment may succeed in early cases if the obstruction is due to spasm or to an active inflammatory process which recedes. In early cases in

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which an active inflammation exists, a feeding jejunostomy is often advisable in order to maintain nutrition. During the stage of active gastritis surgical procedures on the stomach itself may lead to peritonitis due to leakage around sutures which are placed in the inflamed tissue. With a jejunostomy present the stomach should be kept in a resting state. Later definitive surgery can be performed when the gastritis has subsided and the involved region has become demarcated. In some cases Meyer and Steigmann<sup>5</sup> suggest "sham feedings" during this period in order to distend the small gastric pouch. Subsequently the surgical treatment is concerned with relief of the obstruction caused by cicatricial stenosis of the stomach. Gastroenterostomy has been the operation of choice since it is believed that with no or very low acidity present there is slight danger of gastrojejunal ulceration.

#### CASE REPORTS

CASE 1. W. L., a white male, age fifty, accidentally drank a glass of household ammonia during a period of acute alcoholism. He received emergency therapy at another hospital and was discharged after two weeks. He continued to complain of burning epigastric pain, dysphagia and vomiting. Because of these complaints he was admitted to Receiving Hospital on August 1, 1945, seven weeks after the injury. Although he had been a heavy drinker for years, there was no history of any gastrointestinal disturbance prior to the present illness.

Except for tenderness in the epigastrium and evidence of recent severe weight loss, the physical examination was not remarkable. The blood count was within normal limits. There was a trace of albumin in the urine. Gastric analysis showed no blood, a very small amount of free hydrochloric acid and a high total acidity (up to 100 units). X-ray examination of the esophagus, stomach and duodenum following the ingestion of barium showed no evidence of disease of the esophagus. There was considerable dilatation in the proximal portion of the stomach and an excessive amount of secretion appeared to be present. The six-hour study showed almost complete retention of

barium in the stomach, with marked constriction in the distal half. A diagnosis of obstruction at the incisura angularis was made and thought to be due to a very large malignant growth. The x-ray is shown in Figure 1.

He was given daily 3,000 cc. of a solution intravenously containing 5 per cent amino acids and 5 per cent dextrose. A liquid diet was permitted. The daily oral intake never exceeded 800 cc. and it was evident that he was not absorbing these feedings to any great extent since aspirations done each evening yielded 500 to 600 cc. of retained material. There was also an occasional small loss by vomiting.

On August 18, 1945, two and one-half weeks after admission, a laparotomy was performed under continuous spinal anesthesia. The parietal and visceral peritoneum was normal in appearance and there were no adhesions of the stomach to the surrounding structures. The duodenum and about 2½ cm. of the pyloric portion of the stomach were normal to palpation and were freely movable. Proximally, the walls of the stomach were thickened and spongy in consistency. The lumen here seemed to be partially occluded. This thickening extended up the walls of the stomach as far as the junction of its middle and upper thirds. Above this the stomach wall became gradually thinner and near the esophagus it appeared normal.

No attempt was made to resect the stomach or to do a gastroenterostomy because of the apparent activity of the lesion. A feeding type Witzel jejunostomy was done approximately 25 cm. distal to the duodenojejunal junction.

Postoperatively liquid feedings were given by jejunostomy tube. The stomach was kept inactive until September 17, 1945, at which time he was given liquid and soft food orally.

Esophagoscopy done on September 15, 1945, revealed no abnormality. On September 19, 1945, gastrointestinal x-ray was repeated. (Fig. 2.) The stomach proximal to the angularis filled well and showed no abnormalities. Just distal to the angularis there was a narrow tubular constriction for a distance of a few centimeters and a slight widening of the prepyloric area with a normal appearing pyloric canal. At the end of five hours 50 per cent of the barium was retained in the stomach. Gastrointestinal x-rays (Fig. 3) taken about six weeks later showed improvement and it was evident that he could get food through the previously constricted area.



FIG. 1. Preoperative x-ray taken six hours after the administration of barium shows almost complete pyloric obstruction.

FIG. 2. X-ray taken one month postoperatively shows barium leaving the stomach in spite of tubular narrowing distal to the anastomosis.

He was last seen about three months postoperatively. He was eating normally, feeling well and had continued to gain weight. The jejunostomy opening had closed.

CASE II. E. S., a white male, age fifty-nine years, drank one and a half ounces of nitric acid in July, 1939. After emergency treatment was given elsewhere he was discharged. In October, 1939, he was admitted to another hospital complaining of pain in the hypogastrium and flank and vomiting five to twenty minutes after eating. He had lost 30 pounds. X-ray studies showed an organic lesion in the pyloric end of the stomach producing almost complete obstruction. One week later at operation the pylorus was found to be hard and nodular, and it and the duodenum were surrounded by a great deal of inflammatory tissue. A posterior gastroenterostomy was done. The postoperative course was uneventful.

He remained well and worked as a clerk in a store until the latter part of 1944 when he began to suffer with epigastric distress, flatulence and weight loss. This became progressively worse. On April 10, 1945, he entered

Receiving Hospital because of these complaints and because of vomiting after each meal for the preceding two weeks.

Physical examination showed a poorly nourished man in acute distress. He had marked tenderness and voluntary rigidity over the epigastrium. Urine analysis was normal. The hemoglobin was 6.0 Gm. per 100 cc., red blood cells 3,550,000, white blood cells 7,650 and neutrophils 74 per cent. Gastric analysis showed no free hydrochloric acid and a total acidity of 26 units. There was four plus occult blood.

Gastrointestinal x-rays showed a filling defect of the distal segment of the stomach. The anastomotic stoma filled slowly, was small and it required considerable time for the stomach to empty. There was a large ulcerated lesion in the stomach near the stoma.

The patient did not improve on a medical regimen and hematemesis continued. Four weeks after admission laparotomy was done under spinal anesthesia. The abdomen was opened by excising the old midline scar. There were numerous fibrous adhesions in the upper abdomen and the stomach contained a large

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FIG. 3. X-ray approximately two and a half months postoperatively shows some dilation of the previously constricted area in the stomach and a greater amount of barium present distal to the involved area.

flattened tumor mass extending over most of the greater curvature. The organ was movable and there were no gross evidence of metastasis. A gastric resection was done dividing the stomach at a very high level. In order to facilitate the procedure the spleen was removed. The tumor mass in the stomach extended through the gastrojejunostomy stoma, making it necessary to remove about 12 to 15 cm. of the jejunum at the site of the anastomosis. An end-to-end jejunojejunostomy was done. The mesocolic defect was closed and an anterior gastrojejunostomy distal to the new jejunal anastomosis was made. A large quantity of blood was administered during and after the operation.

The final pathologic diagnosis was ulcerating adenocarcinoma of the stomach without demonstrable metastasis to the regional lymph nodes. The postoperative course was stormy and was complicated by wound disruption and evisceration on the eighth day. This healed by secondary intention. He was discharged four weeks postoperatively.

Three months after discharge the patient felt well and was eating normally. He had gained weight and his wound which was well

healed showed a small hernia. X-ray at this time revealed no abnormality and showed an adequately functioning stoma. He returned to light work.

In February, 1946, he again began complaining of indigestion and abdominal pain. He was hospitalized for what was thought to be a recurrence of the carcinoma. Since numerous gallstones had been palpated at the previous operation cholecystitis was suspected to be the cause of his present illness. All x-rays were negative except for the cholecystogram which showed a non-functioning gallbladder. A cholecystectomy, choledochostomy and repair of the ventral incisional hernia were carried out. There was no evidence of tumor. After a stormy convalescence the patient has remained well and has continued to gain weight.

#### SUMMARY

Case 1 may be considered fairly typical of those previously reported. The clinical sequence is similar to the pattern outlined by Boikan and Singer.<sup>4</sup> In this patient a feeding jejunostomy done relatively early seems to have tided him over the period of active inflammation and it seems quite probable that the residual obstruction will not be severe enough to require further surgery. Case 1 is atypical inasmuch as no esophageal abnormalities were noted although he had ingested a strong alkali and developed extensive gastric changes. In this feature it resembles the case described by Vinson and Harrington.<sup>3</sup>

The second case is unusual since to our knowledge it is the first one reported in American literature in which carcinoma followed in the wake of a corrosive gastritis. One is struck by the similarity of the situation to that of malignancy occurring in a chronic leg ulcer or an old scar resulting from a burn. If this similarity is significant, gastric resection should be done if possible rather than a gastroenterostomy for relief of the obstructive symptoms occurring in late corrosive gastritis.

We would like to express our appreciation to Dr. Ivor David Harris, Department of Radiology of the Detroit Receiving Hospital for his cooperation.

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PANCREATIC calculosis is seldom thought of yet it occasionally can cause a patient to suffer epigastric pains, often worse after meals, for many years. Finally, the ducts become occluded and pancreatic secretion ceases because of atrophy of the acinar cells; diabetes may co-exist. X-rays may confirm the diagnosis. Codeine will relieve most patients. Subtotal pancreatectomy is occasionally indicated but at the Johns Hopkins Hospital, according to Martin and Canseco, the preferred operation is ligation of the pancreatic ducts. This stops the pain and yet often forestalls development of definite diabetes. Pancreatic extract, diet and a suitable medical regimen are prerequisites for such cases both before and after operation. (*Richard A. Leonardo, M.D.*)

# DISTURBANCES OF THE PANCREAS AND THE USE OF THE AMYLASE TEST\*

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THE pancreas is an organ located deep in the abdominal cavity. Because of this anatomic position injuries to the pancreas are uncommon. Most injuries to the pancreas are associated with damage to other abdominal viscera. Penetrating wounds usually involve the stomach, liver, spleen, transverse colon or small intestine as well as the pancreas. However, the proximity of the body of this organ to the first lumbar vertebra makes it increasingly possible for the pancreas to be torn or ruptured by non-penetrating trauma to the abdomen. In such cases the pancreas may be injured apart from any other viscera. In either group the signs and symptoms are not sufficiently pathognomonic to enable one to recognize disturbances of this organ. In recent years the elaboration of the serum amylase test has helped to establish the diagnosis in many cases. The method usually employed is the saccharogenic procedure of Somogyi in which an elevation above 180 units is considered abnormal. The rise in blood serum amylase following disturbances of the pancreas is usually considered a result of leakage of the enzyme from the acini into the interstitial spaces or into the peritoneal cavity, thence, the amylase is absorbed into the blood stream.

Considering the probable origin of the increase of blood serum amylase, it was deemed interesting to compare the values of blood serum amylase and abdominal fluid amylase in disturbances of the pancreas.

## CASE REPORT

W. J., a seventeen year old, colored male was admitted on August 9th with a history of

having been struck in the upper abdomen three hours previously when he ran into a wagon. He developed severe abdominal pain and vomited three times. The pain was sharp and non-radiating. In the course of falling he also struck his head but was not rendered unconscious. The remainder of the history was essentially irrelevant; there were no previous gastrointestinal complaints or injuries to the abdomen.

On admission he complained of acute pain non-radiating in character in both upper quadrants of the abdomen. He appeared acutely ill. His temperature was 98.6°F., pulse 82 and blood pressure 110/70. The positive findings were limited to the abdomen. There was exquisite tenderness over the entire abdomen most marked in both upper quadrants. The recti were guarded but there was no involuntary rigidity. Rebound tenderness was not present. X-ray examination of the abdomen and skull was negative; white blood cells were 7,000, red blood cells 4.1 million, hemoglobin 80 per cent, polymorphonuclear leukocytes 60 per cent, transitionals 5 per cent, lymphocytes 30 per cent and monocytes 5 per cent. The following day the blood count was white blood cells, 8,200, polymorphonuclear leukocytes 60 per cent, transitionals 70 per cent, lymphocytes 30 per cent.

The abdominal signs cleared by the following morning and the patient was observed for three days. He remained comfortable until the 13th of August when he signed himself out of the hospital.

On August 15th he suddenly developed acute abdominal pain in the left upper quadrant. He stated that he had continued to have pain in the upper abdomen, had vomited several times, had been feverish, and had had diarrhea for two days.

On admission he presented a picture of an acutely ill young man. His temperature was 100°F., pulse 100, respiration 20 and blood pressure 120/72. The entire abdomen was

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tender and there appeared to be a bulging, tender mass in the left hypochondrium extending to the flank posteriorly. Rebound and cross rebound tenderness were present. There was moderate distention and on rectal examination tenderness was found to be present in the

TABLE 1

Date	Blood Amylase	Amylase from Wound	Urine Amylase
8/20			
8/21	338		
8/22	269		
8/25	478	.....	502
8/28	226	14,400	940
8/29	400	5,880	
9/2	425		
	268		
	265		
9/3	295	5,280	
9/4	337		
9/5			
9/8	315		
9/9	241	2,240	
9/11	280		
9/12	244		
9/15			
9/16	308		
9/24	341		
9/29	245		

left cul-de-sac. X-ray of the abdomen was negative.

On operation a fully distended lesser peritoneal sac was found containing 700 cc. of serosanguineous fluid with many pieces of dark brown exudate. The lesser sac was indurated and swollen. The foramen of Winslow was closed and blocked. There was a laceration in the posterior peritoneal attachment of the descending colon and free serosanguineous fluid was present in the abdominal cavity.

A 5 inch left rectus muscle-splitting incision was made down to the peritoneum. The abdomen was explored and in attempting to palpate and visualize the spleen the lesser sac was ruptured. Aspiration of the free fluid was accomplished. The lesser sac was opened and all the exudate was removed. The small intestine was further explored from the ligament of Treitz to the cecum. The laceration of the posterior attachment of the descending colon was repaired and the abdomen closed in layers. Three cigarette drains were placed in the lower left lumbar gutter, the foramen of

Winslow and the left flank. A dry, sterile dressing was applied and the patient left the operating room in good condition. The patient received about 500 cc. of 5 per cent glucose intravenously during the operation which was performed under ether anesthesia.

The patient's temperature varied from 100.2°F. on the first day to 101°F. on the seventh day and remained normal thereafter. The wound continued to drain serosanguineous fluid to clear fluid until the forty-second day and then gradually decreased in amount. Upon discharge from the hospital there was no drainage. Methylene blue taken orally did not appear in the abdominal discharge. The chemistry findings were normal; urea nitrogen was 19, creatinine 1.3 mg. per cent, blood sugar 115 mg. per cent, icteric index 6, Vandenburg negative and a normal glucose tolerance. The discharge was aspirated from the abdominal wound and analyzed for amylase. Table 1 is a comparison analysis of the blood amylase and fluid obtained from the abdominal cavity.

#### COMMENTS

The case reported herein illustrates difficulties encountered in diagnosing injuries to the pancreas. When injuries result in trauma to other viscera, the diagnosis of disturbance of the pancreas may be encountered secondarily at operation. However, the trauma may be surprisingly slight and occasionally is not sufficient to injure other organs. In these cases we must use all our clinical and laboratory aids to assist us in our diagnosis. The use of the serum amylase test frequently helps, depending on the stage which the disease has reached when blood is analyzed. The findings of a markedly elevated amylase determination from the abdominal fluid should aid materially in diagnosing cases of pancreatitis where serum amylase determinations are equivocal or low. It is suggested in suspected cases of pancreatitis that abdominal taps be performed in all four quadrants in an attempt to aspirate fluid. The fluid obtained in this manner, if it exceeds 3 cc., should be analyzed for amylase and the values interpreted in conjunction with the serum amylase determinations. It is seen

in this case that the abnormal fluid amylase is more markedly increased than the blood serum amylase and that at times when, the serum amylase values approach normal, the abdominal fluid amylase is still markedly elevated.

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reums infunditulem corpora mamillaria and contiguous areas, pineal, testes and ovary. There is a very close relationship between the adrenals and sexual glands, more closely associated in the female than in the male, and cortical tumors in the female are prone to cause secondary masculine sexual characteristics while in the male they usually cause premature sexual development along male lines. In the adult the adrenal cortical tumor is prone to cause the syndrome which closely mimics Cushing's syndrome, the characteristics of which Kempton and Lohr<sup>12</sup> described as plethoric adiposity of the face, neck and trunk, purplish striae, acrocyanosis, polycythemia and vascular hypertension, frequently accompanied by hyperglycemia and osteoporosis, and in women by amenorrhea and hypertrichosis. This description followed the finding of a basophilic adenoma of the pituitary at autopsy in three cases which presented the same symptomatology. It is now known, as stated before, that there might be such mimicking of symptoms by other tumors, therefore, one always has to bear this factor in mind. The diagnosis can often be more clearly made by pyelogram studies and perirenal instillation of air has been carried out; but this is not without some danger and often the data obtained are not clear cut and we have been a little bit reluctant to use it.

The adenogenital syndrome, or adrenal virilism, in children consists of male or female precocity. Forty cases in girls and seventeen cases in boys have been reported.<sup>13</sup> In young women hirsutism of varying degrees, amenorrhea, deepening of the voice, enlargement of the clitoris, acne and masculine bodily contour and musculature and extensive disturbance of metabolism, as seen in Cushing's syndrome, are present. Again, when this condition is suspected, a tumor arising in one of the other glands has to be considered.

Adenomas of the cortex which produce no endocrine symptoms are found only as incidental findings at autopsy; they

occur not uncommonly as reported by H. E. Robison.<sup>14</sup>

*Medullary Tumors.* Medullary tumors, called pheochromocytomas, are characterized by symptoms of paroxysmal hypertension and tachycardia, vasomotor disturbances, sweating, nausea, headache and glysuria. At first the symptoms are intermittent but as the disease progresses the hypertension is likely to be persistent because of permanent damage. Kepler and Keating<sup>13</sup> have reported on 103 cases. They commented that sometimes symptoms can be produced by pressing over the tumor, and that the results from the removal of these tumors are highly successful.

In a previous case reported by one of us<sup>15</sup> of a tumor of the medullary type, a paraganglioma (pheochromocytoma), arising in the renal pedicle was found only after careful bilateral exploration. The blood pressure before removal had been in attacks as high as 260/160. Almost without exception there is an immediate severe drop in blood pressure upon removal of these tumors which must be combatted by fluids, adrenalin, blood and other supportive measures. In addition a later adrenal insufficiency must at times be combatted. This patient has remained well for more than three years with the exception of a very marked sickle cell anemia. Her blood pressure now is 130/90.

#### TREATMENT

The treatment of these conditions is always surgical and, as stated, a bilateral exploration of the adrenals is at times necessary for definite diagnosis. Walters<sup>16</sup> reported on nine hyperfunctional cortical tumors and three medullary tumors without any fatality from removal. All of the cortical tumors revealed malignant changes while all of the medullary tumors were encapsulated and benign. In the case we are reporting the tumor was a very large one, densely adherent to the inferior vena cava and also with evidence of metastasis to the mesenteric lymph glands. The primary

growth was readily removed through a transperitoneal approach. Because of the enormous size and adherence to the vena cava, a portion of its wall was removed; this defect was repaired. Using the lumbar incision commonly used in exposing the kidney, the retroperitoneal approach will give excellent exposure in tumors which are of small size. Further exposure can be facilitated by resection of the twelfth rib. Young<sup>17</sup> has devised an incision and retractor for exploration of both glands at the same operation.

There is little excuse for patients to die from adrenal tumors without exploration just because the condition is thought to be one of tumor of the pituitary body. If all these cases are explored, there will be many that will not be benefited because no adrenal tumor will be found; and it has been stated that in cases of basophilism the incidence of infection is high. Where no adrenal tumor is found at exploration, the peritoneum may be opened and the ovaries carefully explored for the presence of arrhenoblastomas.

#### ADRENAL INSUFFICIENCY

It was formerly believed that 90 per cent of cases of adrenal insufficiency, commonly called Addison's disease, was due to tuberculosis of the adrenals, but it is now believed that primary adrenal atrophy is responsible for about half the cases. The management of this syndrome has contributed immeasurably to our knowledge in the treatment of immediate postoperative cases. When there is hyperfunction in an adrenal tumor, the opposite adrenal might become somewhat atropic and this is the reason these patients go into an adrenal insufficiency. If the tumor proves malignant, the possibility of metastasis to the opposite adrenal gland exists. Walters<sup>16</sup> has emphasized the fact that one should always be on the lookout for the possibility of adrenal insufficiency after surgery and that every preoperative and postoperative preparation should be made for this complication. Complications can largely be

prevented by giving extract of adrenal cortex, sodium chloride and sodium citrate intravenously, together with a low administration of potassium.

#### CASE REPORT

The patient, age twenty-nine, was a school teacher. Her chief complaint was "pain in the right side of the back just below the lower ribs." This was first noticed April 1, 1945. It was a dull, aching character, constant as to location and extent and continuous as to time of occurrence. The usual home remedies were resorted to, including aspirin, local heat and various liniments, none of which gave consistent relief. Several physicians were later consulted. After thorough pyelography a urologist observed that the pain could be relieved either by opiates or by abdominal support. Later she was placed at continuous bed rest for three months, the foot of the bed being elevated, in the hope that this would give support and elevation to the ptosis of the right kidney. The pyelogram showed marked downward displacement of the right kidney.

At the end of three months of bed rest she consulted one of us for the first time. At this examination (November 21, 1945) the findings included the following:

The patient was a well developed but undernourished white female who leaned to the right in standing and assumed erect posture only with some difficulty. There was no suggestion of acute febrile illness. The skin was of a dusky lemon hue, suggesting the possibility of adrenal cortical disturbance and was diffusely loose and dry, lacking the normal warmth and moisture characteristic of more healthy integument and suggesting recent loss in weight. The epigastrium presented a mass which was palpated with difficulty and was apparently deep and perhaps retroperitoneal in location. It was the size of a grapefruit. There was apparently a separate mass a little larger and to the right of the mass already described at a simpler depth. The lower abdomen was free from any masses, areas of tenderness or irregularities of contour. The inguinal and clavicular areas were free of adenopathies. Pelvis and rectal examination showed no evidence of primary or metastatic disorders. Extremities were negative. X-ray of the stomach showed dilatation and displacement to the left.

# TUMORS OF THE ADRENAL GLAND

## CARCINOMA OF THE ADRENAL CORTEX

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THE symptomatology of adrenal tumors is so variable and the condition so uncommon that unless it is kept constantly in mind many cases will go unrecognized for a considerable length of time. They produce symptoms practically

functions of the adrenal and this has been reproduced by him in Table I.

When an adrenal disease is suspected, Lukens has emphasized that the physician should first inquire into the manifestations of sexual, metabolic and electrolyte dys-

TABLE I  
FUNCTIONS OF THE ADRENALS\*

Site	Major Activity	Chemical Substances	Effects	
			Physiologic	Clinical
Medulla	Sympathomimetic	Epinephrine	Pressor action	Pheochromocytoma Neuroblastoma
Cortex	Water and salt regulation	Desoxycorticosterone	Life maintenance Sodium retention	Deficiency = Addison's disease
Cortex	Metabolism	Corticosterone	Diabetogenic Work test	Cushing's syndrome?
Cortex	Sex	Androgens Estrogens	Male and female sex activity	Virilism (women) Feminism (men)

\* From F. D. W. Lukens, M.D.

identical with those produced by arrhenoblastomas of the ovary, thymic tumors and Cushing's syndrome of basophilism.

According to Wilhelm and Gross<sup>1</sup> a case of an adrenal gland tumor was reported as early as 1756 by William Cooke<sup>2</sup> in a seven year old girl. Since that time many other cases have been reported.<sup>3-9</sup> In 1942 Reilly<sup>10</sup> reported a striking case of adrenal cortical tumor occurring in a child at the age of fifteen months. The first successful operation on an adrenal gland tumor was done in 1899.<sup>1</sup> It is noted that in recent years many more cases are being reported than previously and that most of them have been in women.

Lukens<sup>11</sup> has tabulated very well the

function in the patient. His classification of tumors of the adrenal gland appear in Table II.

### SITE

*Cortical Tumors.* Tumors arising from the cortex, one of the two distinct parts of the adrenal, may have entirely different symptomatology from tumors of the medulla, the second portion. One of the striking symptoms in adrenal cortical tumors in children is marked sexual precocity, including rapid skeletal growth, acne and marked genital development, together with the formation of pubic hair. However, other causes for sexual precocity have been lesions in the hypothalamus, tubercine-



TABLE II  
DIFFERENTIAL DIAGNOSIS OF ADRENAL TUMORS\*

Tumor	Clinical	Roentgenologic	Laboratory
General symptoms and findings	<div>Virilism</div> <div>Cushing's syndrome</div> <div>Virilism or hirsutism</div> <div>Amenorrhea</div> <div>Obesity</div> <div>Hypertension</div> <div>Glycosuria</div> <div>Striae</div> <div>Osteoporosis</div>	Bone age (under 21) Increased bone density Osteoporosis Arteriosclerosis Metastasis	Routine studies clinically indicated Urinary hormone excretion†: Androgens & estrogens by bio-assay 17-Ketosteroids (17-KS) by chemical methods
Adrenal cortical tumor or hyperplasia	A. Virilism Sexual precocity in boys Growth; brief spurt at first, then retarded Amenorrhea (with virilism) Virilism or precocity in girls B. Cushing's Syndrome All classical symptoms Weakness Visual fields normal C. Non-functioning Tumors If benign, are undiagnosed If malignant, usual symptoms of tumor are hematuria, metastasis especially to lungs	Chest for metastasis Premature epiphyseal union (virilism) Osteoporosis (with Cushing's syndrome) Urogram Perirenal air injection Body section roentgenography (the last three procedures in combination advised by roentgenologist) Pituitary fossa normal	Androgens and 17-KS greatly increased. Estrogens increased by some methods Glucose tolerance test Renal function tests (hypertension) Androgens increased, 17-KS increased Hematuria Hormones not studied
Pinealoma and fourth ventricle tumor	Usually in children Sexual precocity Neurologic signs Papilledema Increased intracranial pressure Visual fields	Signs of increased intracranial pressure Possible increased calcification and displacement of pineal gland Ventriculogram Pituitary fossa—often enlarged	Androgens increased (M) Estrogens increased (F) 17-KS normal
Basophilic adenoma, (Cushing's disease)	Cushing's syndrome Visual fields usually normal	Pituitary fossa abnormal Osteoporosis Arteriosclerosis Therapeutic test of irradiation	Glucose tolerance test Renal function test 17-KS increased
Thymic carcinoma‡	Cushing's syndrome Increased mediastinal dullness	Like Cushing's syndrome Mediastinal enlargement	Like Cushing's syndrome (above)
Arrhenoblastoma of ovary	Pelvic examination Pelvic exploration	Metastasis When Cushing's syndrome occurs osteoporosis, etc.	17-KS normal (Presumably increased if Cushing's syndrome present)

\* From: F. D. W. Lukens, M.D.

† Hormone assays are not widely available but are an active field of investigation

‡ Only 4 cases reported. Thymic tumors without Cushing's syndrome are without endocrine symptoms

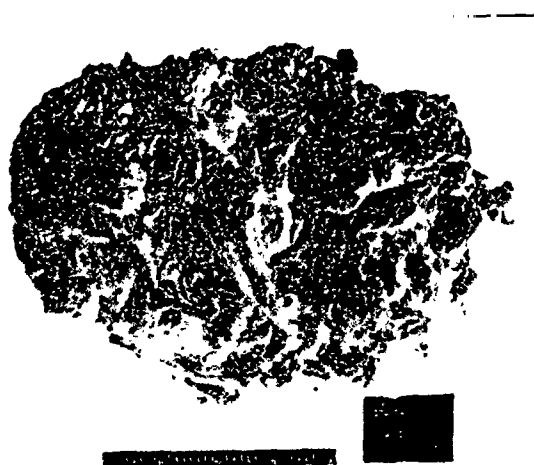


FIG. 1. Photograph of mass superior to the right kidney.

The hemoglobin was 58 per cent; the red blood cells numbered 2,850,000, white blood cells 8,200; differential cell study was normal.

A diagnosis of retroperitoneal tumor was made. Exploration was done December 11, 1945.

Under general anesthetic a straight midline abdominal incision was made. The stomach was markedly enlarged and displaced to the left and downward. There was no peritoneal metastasis or mesenteric adenopathy. The liver and spleen were not enlarged. The large and small intestines appeared normal. A retroperitoneal mass was present so an incision was made through the posterior peritoneum. An irregular adenopathy was present just to the left of the midline and at the level of the first to third lumbar vertebrae. Anteriorly, the mass appeared circumscribed and its posterior surface was not entirely explored. There was a second mass entirely circumscribed and motile just above the right kidney. As the mass appeared markedly soft and caseous and as the possibility of tuberculosis was considered, biopsies were made with a plan not only of fixed tissue study but of animal inoculation as well. No attempt was made at resection at this exploration.

The patient was given two blood transfusions and repeated injections of liver and iron. A laboratory report of liposarcoma was made and the guinea pig inoculation was reported negative. Repeated transfusions brought the blood to normal. Re-exploration was advised and carried out December 29, 1945. A careful examination was made for evidence of peritoneal and visceral metastasis and as none was found we proceeded with resection. A clean resection

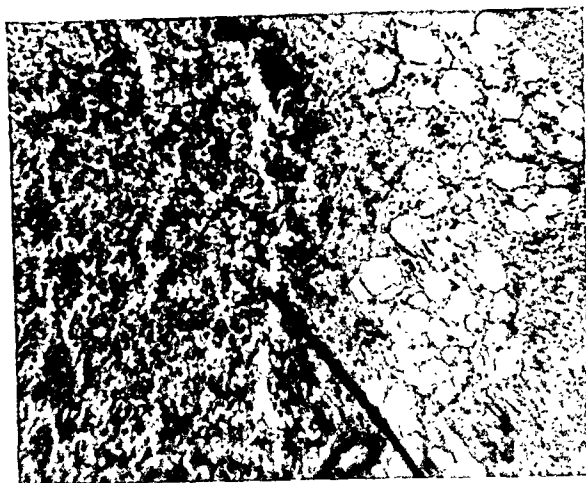


FIG. 2. Photomicrograph showing adenocarcinoma of the adrenal cortex, grade III.

was made of the mass superior to the right kidney; it was about twice the size of a normal kidney. (Fig. 1.) A search was made for the right suprarenal gland but as the normal suprarenal was not found we considered the mass as of probable suprarenal origin.

The greater portion of the mass just to the left of the upper lumbar vertebrae was then resected. As the mass continued in a group of preaortic glands it was believed futile to attempt further resection. The pathologist and radiologist were asked to see the gross specimens and the operative field, as it was believed that complete eradication of the lesion would depend very greatly on our combined efforts. (Fig. 2.)

The patient received 500 cc. of whole blood during the operation and her condition remained excellent throughout.

A pathologic diagnosis of adenocarcinoma of the adrenal cortex grade III was made. (Fig. 2.)

It was agreed that the patient was in good general condition and that best results with deep x-ray could be expected if it was started by the end of twenty-four hours postoperatively.

In addition to two more blood transfusions daily infusions of 5 per cent amino acids in 5 per cent glucose were given throughout the period of deep radiation. It was believed that this might conserve liver glycogen, liver parenchyma and serum albumin and lower the nausea and weakness so frequently seen in intensive deep radiation.

The results in this case were highly satisfactory. There was a minimum of nausea and no edema or chills in the course of prolonged irradiation. The intravenous administration of

amino acid in glucose presented no intrinsic problem or complications.

The patient sat up on the third postoperative day and walked to the bath room the sixth day. She went home as soon as deep radiation was complete which was at the end of the third postoperative week. She has since been seen in the office at weekly intervals. She takes long walks daily and at the present writing is doing most of her housework. There is no evidence of metastasis. Upon dismissal from the hospital her weight was 104 pounds; her present weight is 124 pounds, hemoglobin 82 per cent and red blood cell count 4,520,000. It is planned that she report each month for a year for examination and blood counts. If her progress is then satisfactory, she will be seen each quarter for the next five years.

#### SUMMARY

Tumors arising in the adrenal gland represent a very interesting group. Since the adrenal is divided into two anatomic portions, the cortex and the medulla, we can have tumors arising from either of these component parts. Those arising from the adrenal cortex which are benign rarely cause any symptoms and are found only at autopsy. The other great group of cortical tumors are malignant and give rise in children to a marked precocious development as characterized by marked growth of sexual organs, increased osseous growth and in the female in sexual development which often tends toward the masculine side. In the adult a chain of symptoms commonly called Cushing's syndrome may develop consisting of plethoric adiposity of the face, neck and trunk, purplish striae, acrocyanosis, polycythemia and vascular hypertension, frequently accompanied by hyperglycemia and osteoporosis, and in women by amenorrhea and hypertrichosis.

Other glands of internal secretion such as the ovaries, testicle, thymus and pituitary may also give rise to symptoms which so closely resemble adrenal cortical tumors that it is practically impossible to distinguish between them. This is the reason that so often surgical exploration of both adrenal glands is necessary to prove

or disprove its presence, and exploration should be encouraged even though a certain number of patients will be disappointed because no adrenal disorder will be found. Otherwise tumors of the adrenal will be overlooked.

Tumors arising from the medulla (pheochromocytoma) are usually benign. Symptomatology includes attacks of paroxysmal hypertension and tachycardia, characterized by sweating, nausea, headache and glycosuria. Their removal produces satisfactory results provided they have not caused a severe cardiovascular damage.

Most tumors of the adrenal cortex which produce symptoms have been malignant and the prognosis, of course, has been bad. In contrast, tumors of the medulla are usually benign.

#### CONCLUSIONS

A partial review of the literature is presented, a case of non-functioning adrenal cortical tumor is reported and the progress of a case of medullary tumor has been referred to. The difficulty in diagnosis and of differential diagnosis, due to the same chain of symptoms encountered in so many tumors arising from glands of internal secretion, is stressed. Successful removal of an adenocarcinoma of the cortex of the adrenal gland grade III followed by x-ray treatment is reported. Surgical removal of a medullary tumor causing episodes of paroxysms of hypertension is referred to and the course of cure over a period of three years is reported.

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TUMORS of the adrenal cortex frequently produce sexual hormonal syndromes often combined with metabolic effects; occasionally only the latter symptoms are discernible. These cases may be related to lesions or tumors of the pituitary or the pineal gland or to the gonads. However, if the urine shows more than 200 international units of androgen in twenty-four hours, the probabilities are good that the lesion is in the adrenal cortex. Bilateral exploration may be needed, especially if x-ray pictures following air injection into the perirenal fat on each side are negative. The left side should be explored first since tumors of the left adrenal cortex are the more common. Often bilateral hyperplasia of the tissue occurs without actual tumor formation. (Richard A. Leonardo, M.D.)

# UNUSUAL CONDITION OF COLON FOLLOWING RESECTION OF SIGMOID FOR ADENOCARCINOMA

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THE patient whose case is reported herein has been observed for over four and a half years. During this period he had three abdominal operations including complete colectomy and sigmoidectomy; but the cause and effect sequence between the pathologic changes leading to these operations is still not quite clear.

## CASE REPORT

In December, 1942, when the patient first presented himself for examination, he was fifty-seven years old. He complained of progressive constipation of three months' duration. The preceding history included "some trouble with the right kidney and an operation for tumor of the left shoulder both in 1941. Since the appearance of constipation he also had gas and pressure on the stomach. He had to urinate about four times during the day and also four times during the night. Otherwise there were no complaints or significant data. It was difficult to obtain a good history from the patient.

Examination showed a male patient, very well preserved for his age but in a poor state of nourishment; he weighed 147 pounds, having lost 30 pounds within the year preceding the examination. Head, chest and abdomen did not show any unusual features. Digital rectal examination gave the impression of a small mass barely palpable. On sigmoidoscopy the scope was introduced for a distance of 15 cm.; bloody, foul-smelling fluid stools seeped in small amounts from above; the mucous membrane appeared injected but not changed in any other manner. Attempt at further introduction was not successful since it caused pain. The blood pressure was 120/80; urine specific gravity 1021, acid, negative for albumin, sugar and pus. The Wassermann reaction of the blood was negative. The blood count disclosed 3,250,000 red cells and hemoglobin of 10 Gm. per 100 cc., otherwise it was not remarkable.

A barium enema and a radiologic examination of the large bowel tract was done. There was no obstruction to the inflow of the barium. Under the fluoroscope the rectosigmoid flexure appeared somewhat irregular. Films taken on the filled large bowel did not show any particular change from normal, except for a generally wide caliber of the colon tract; haustration appeared to be normal. The patient was not able to expel the enema fluid. Following this examination the patient took a cathartic and three enemas in four days. On examination thereafter he still had barium solidly filling the colon tract to near the rectosigmoid junction.

The patient was admitted to the Alexian Brothers Hospital. Following preparation a laparotomy was done on January 8, 1943. A hard mass about 5 cm. in diameter was palpated in the sigmoid near the rectosigmoid junction. There were no palpable or visible deposits suggestive of malignant spread in the abdominal organs. A 15 cm. length of the sigmoid including the rectosigmoid junction and the mesosigmoid were resected after ligation of the superior hemorrhoidal artery. An aseptic anastomosis was done over clamps between the descending colon and the rectal stump; the reconstructed peritoneum buried the suture line, due to its low position, in the pelvis. The pathologic report was: Gross: infiltrating carcinoma of sigmoid with probable extension into surrounding and regional lymph nodes, microscopic: adenocarcinoma, grade 2, with metastasis to adjacent lymph nodes.

The patient had a very smooth recovery and left the hospital sixteen days postoperatively with a well functioning colorectal anastomosis and a well healed operative incision. In three months following the operation he gained 21 pounds and his blood picture became normal. On follow-up a small singular polyp was found in the rectum; this was removed by diathermy snare and its base coagulated on June 9, 1943. The patient was regularly followed till December, 1943, when he weighed 176 pounds and



FIG. 1. Barium enema taken January 2, 1946.

appeared to be free of recurrence and well in every other respect. Further follow-up was interrupted by war conditions.

On December 31, 1945, this patient reported again for examination. He stated that he had no complaints until December 25, 1945, when he started to look pale. Three days later he was seized with generalized abdominal pain and cramps which were persistent throughout up to the examination. He had normally formed bowel movements until the abdominal pain started. Since then enemas were used to bring about a bowel movement. During the further clinical course, in view of later findings, the patient was repeatedly questioned as to whether this history was correct, whether he did not have abdominal pain, change in bowel habits or in appearance of fecal matter prior to December 25, 1947. The patient always asserted that this history was correct. On physical examination he appeared acutely ill. His abdomen was distended and there was generalized tenderness but no board-like rigidity. It was believed he had intestinal obstruction and was immediately admitted to the Newark Beth Israel Hospital. There he was placed on Wangenstein suction and intravenous alimentation and his general condition improved.

On January 2, 1946, a barium enema was given (Fig. 1.) A Wangenstein tube was observed *in situ* with the tip in the stomach. Exposures of the colon with the aid of a barium

August, 1949



FIG. 2. Status following the operation on January 8, 1946.

enema showed no obstruction. The cecum and proximal transverse colon were markedly distended. There was irregularity in filling of the entire descending colon from the splenic flexure and also a narrowing of the distal descending colon and sigmoid. Although not definitely characteristic the changes of the descending colon were in all likelihood due to a chronic inflammatory lesion with multiple sessile polyps. The change in the sigmoid was probably due to the previous operative procedure.

Wangenstein suction and intravenous alimentation were continued. On January 4th a sigmoidoscopy was done and the scope introduced for a distance of 15 cm. There were no polyps noted. The former anastomosis could not be identified. Patches of the mucous membrane appeared inflamed and edematous. On January 8th the patient was subjected to a laparotomy. It was found that the descending colon in its entire length was contracted and felt like a rubber hose containing small pebbles. A part of it was brought into view; this was angry red and injected; a few greenish-yellow, well circumscribed patches were seen on the serosa which were interpreted as impending perforations. The liver and spleen particularly but also the mesentery of the colon and small bowel and abdominal organs in general were carefully palpated and inspected as far as the incision permitted. There was nothing found outside of the colon that would have indicated



FIG. 3. Barium enema taken March 29, 1946.

recurrence of the malignancy. The change in the colon itself was considered inflammatory.

In order to counteract the impending perforations and to relieve the obstruction the following was done: The descending colon and the rectum were bisected approximately at the point of the previous anastomosis; the ileum was bisected about 3 inches cephalad from the ileocecal junction. The cephalad end of the ileum and the rectal stump were connected by a side-to-side anastomosis using one layer of continuous catgut for the mucosa and two layers of interrupted silk for the muscularis and serosa of the bowel. (Fig. 2.) The caudal end of the ileum was brought out in the right lower quadrant as a terminal ileostomy, the end of the descending colon in the left lower quadrant as a terminal colostomy. Thus a continuous fecal stream was established into the rectum but the entire length of the colon was shunted out of the fecal stream. One heavy cigarette drain was placed into each the right and left lumbar gutters and brought out at the lower end of the abdominal incision. Two rubber tubes each about  $\frac{3}{4}$  of an inch in diameter were sutured into the rectum to provide ample decompression for the new suture line and a Foley catheter was placed *in situ* into the bladder. Wangensteen suction and intravenous alimentation were continued and other supportive measures added. The patient had a very stormy recovery. Apparently the descend-

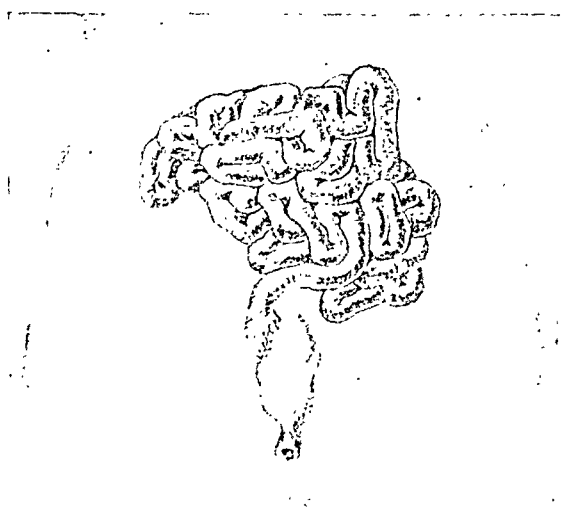


FIG. 4. Status following the operation on May 25, 1946.

ing colon perforated postoperatively giving rise to peritonitis. He was discharged from the hospital on the sixteenth postoperative day at which time he was on a smooth diet including chopped meats. He had two to five soft or liquid stools daily and the colostomy drained large amounts of purulent material. The general condition of the patient improved rapidly although purulent discharge from the colostomy continued.

On March 29th a barium enema of the colon was given through the ileostomy. It revealed that the cephalad colon half was normal; irregularities of the pattern were noted in the caudad half of the transverse colon but there was no gross change in the lumen. The descending colon down to the colostomy appeared to be considerably narrowed and shortened in length. No indication of polypoid changes was present. (Fig. 3.)

The patient was readmitted to the Newark Beth Israel Hospital and on May 25, 1946, he was again operated upon. The entire colon tract including the small length of the ileum between the ileostomy and the ileocecal junction was excised; the ileoproctostomy was not disturbed. The general appearance of the cephalad colon half was normal; the caudad colon half particularly the descending colon was contracted and shortened. The pathologic report was: Gross: specimen consisted of 15 cm. of terminal ileum and 90 cm. of the cecum and colon. The ileum as well as the terminal end of the colon showed a stoma each measuring 4 cm. in diameter surrounded by attached portion of skin measuring 1 to  $1\frac{1}{2}$  cm. in width

which were the two enterostomy openings. Seven cm. proximal to the terminal opening the bowel was constricted, narrowing the lumen for a distance of 18 cm. There the mucous membrane was thickened, flattened with linear ridges, and several erosions varying from 4 to 6 mm. in diameter were noted. The mucous membrane of the other portions of the colon were edematous with occasional erosion adjacent to the constriction. The ileum showed no gross abnormalities. Microscopically, there were areas of acute and subacute enteritis. (Fig. 4.)

The patient made a very uneventful recovery and left the hospital on the sixteenth post-operative day. Follow-up showed him to be well, his only complaint being that fruits and certain vegetables cause diarrhea; otherwise he has one or two formed stools daily. There is no stricture at the ileo-proctostomy site; this can be reached by finger. The patient is working and clinically free of recurrence in April, 1949.

#### COMMENT

From the oncologic point of view this patient represents a more than four-year cure from adenocarcinoma of the sigmoid with metastasis to adjacent lymph nodes. This was obtained by anterior resection and direct anastomosis. It indicates that this procedure is useful in certain cases. From the surgical point of view the second operation presents interesting features. The feasibility of a direct ileoproctostomy under difficult circumstances is demonstrated. The absence of leakage from the anastomosis, I believe, was brought about principally by large caliber rectal drainage and prevention of tension thereby on the suture line. There are several points of clinical interest. It is amazing that a human being, no matter how hyposensitive he is, can develop a condition as existed in this patient on December 31, 1945, and cause practically no symptoms prior to obstruction. It seems hardly conceivable that inflammatory granulations and polyps as indicated by the barium enema on January 2, 1946, and by the operative findings four days after had not caused severe

complaints. Conversely, it also seems hardly conceivable that they would have developed in a few days. The colon, resected on May 25th, showed acute and subacute inflammation with ulcerations along its entire length. This probably existed for some time before the obstructing polyps appeared in the descending colon, yet this patient had no loose bowel movements nor any abdominal discomfort up to the time when obstruction intervened. With the relief of the obstruction the complaints disappeared. The polyps receded after surgical drainage of the colon accompanied by protracted purulent drainage. Inflammatory polyps like those in chronic ulcerative colitis are known to recede. When the sigmoid was resected on January 8, 1943, the gross specimen showed an exulcerated cancerous mass about 50 mm. in diameter in the middle of which was a nipple-like projection. This probably was a true polyp with a broad base. The rectal polyp removed on June 9, 1943, seemed to be a true polyp. It was not examined pathologically because the diathermic current desiccated it. The colon changes in 1946, however, were inflammatory. Therefore, it seems that this patient developed an inflammatory lesion of the entire length of the colon in some respects similar to those of ulcerative colitis after he was cured of an adenocarcinoma of the sigmoid developing from a broad-base polyp. The two processes were probably entirely independent of each other.

#### SUMMARY

An adenocarcinoma of the sigmoid with metastasis to adjacent lymphnodes was treated by anterior resection in January, 1943. The patient is free of recurrence. An inflammatory lesion of the entire colon tract led to obstruction of the descending colon in December, 1945. This was treated in two stages; first, draining the colon and anastomosing the ileum to the rectum; secondly, removing the entire colon. The clinical result has been good.



# ILEOCOLIC INTUSSUSCEPTION DUE TO METASTASIS FROM EMBRYONAL CARCINOMA OF THE TESTIS

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**I**NTUSSUSCEPTION in adults is a relatively infrequent cause of intra-abdominal surgical emergency. Tumors of the small bowel are the most common cause of this accident with benign neoplasms being more frequently seen than the malignant variety. Metastatic neoplasms are a rare cause of intussusception. Metastasis of an embryonal carcinoma of the testis to the ileum producing intussusception is a medical curiosity.

Embryonal carcinoma of the testis may pursue a relatively benign course for a protracted period and its presence then heralded by rapid, progressive development in distant portions of the body. The most frequent presenting symptom in carcinoma of the testicle is painless enlargement of the organ; in many cases only a small tumor is noted. As pointed out by Auerbach, Brines and Yoguda,<sup>1</sup> metastases follow a fairly consistent pattern. A large, palpable mass is characteristically present in the upper portion of the abdominal cavity straddling the vertebrae. The lungs, mediastinal lymph nodes and the liver also are frequent sites of secondary tumors. Late symptoms and signs may sometimes appear in a catastrophic manner with no indication that the testicular tumor is the underlying cause.

## CASE REPORT

Such a sequence of events was found in a nineteen year old, white soldier who stated that he had been ill for approximately six days prior to admission. The illness was initiated by paraumbilical pain of moderate degree, nausea and vomiting. The patient was seen by his battalion surgeon who noted no great change in the condition of the patient in the subsequent five

days. The patient stated that he continued to eat but that the meals frequently were followed by emesis. He had had a watery stool the day before admission but blood had not been noted in the fecal material. A mass was found in the right lower quadrant of his abdomen by his battalion surgeon on the day of admission to our installation. Treatment prior to this time included the administration of fluids by the intravenous route, penicillin and morphine.

The patient stated that about ten months before admission he had been struck in the left testicle by a box. The organ became quite tender and was swollen on the following day but returned to normal size subsequently. There had been no change in the size of the testis since that period.

Physical examination revealed an acutely ill, drowsy, dehydrated, white male whose pupils were miotic and whose throat was diffusely red. Visible abdominal peristalsis was not present. A large, tender mass was palpable in the right lower quadrant of the abdomen and rebound tenderness was referred to this sector from all of the other quadrants. A moderate degree of tenderness was found on the right side of the rectum but blood was not found on the examining finger. A small discrete nodule measuring about 2 cm. in diameter was palpable in the left testicle.

The differential diagnosis presented by this patient was extremely interesting. He had been ill for a period of approximately six days with no great progression of symptoms. Physical signs during this period had remained about the same except for the presence of a mass in the abdomen which was first noted on the day of transfer. Recapitulation of the history revealed that the patient had had paraumbilical pain with nausea, vomiting and the presence of a mass which had appeared rather late in the course. The history and physical findings as revealed upon admission suggested that the patient might have had acute appendicitis

with perforation and abscess formation. Support was given to this diagnosis by the relatively benign course which the individual had pursued for six days. However, the presence of some of the characteristic symptoms and signs of intussusception were noted. The exact role of the nodule in the left testis which was suspected of malignancy was not well understood at this time. However, it was apparent that this individual had suffered some acute intra-abdominal catastrophe. After suitable preparation a right muscle-splitting McBurney type of incision was made; the mass was approached in a retroperitoneal manner with the idea that if purulent material were encountered in an abscess from a perforated appendix, drainage and perhaps appendectomy could be performed. No abscess was found. Therefore, the peritoneum was opened widely and the mass was found to be an ileocolic intussusception. Reduction was impossible. The 20 cm. of ileum just proximal to the area where the small intestine entered the intussusception was moderately cyanotic and the proximal portion of the small bowel was slightly dilated. With delivery of the mass from the peritoneal cavity, the cyanosis of this area of small intestine disappeared and a normal color returned. The areas of the involved ileum, cecum and appendix in the mass were resected between Payr clamps. The free edge of the mesentery of the resected portion of ileum was sutured to the lateral peritoneal wall and the free ends of the ileum and cecum brought out of the abdomen together with the two portions of the bowel sutured in an approximated position. The peritoneum, muscle, fascia and skin were closed about the protruding ends of the bowel.

Measurement of the specimen after operation when the ileum was cut and the intussusception reduced revealed that about 34 cm. of gangrenous ileum had been removed. A small tumor measuring about 1.5 cm. in diameter was present at the head of the intussusception and the serosal surface of the ileum opposite the tumor showed a definite umbilication.

The patient did well in the immediate post-operative period. Intubation with a Miller-Abbott tube was done and the patient was given citrated whole blood and plasma intravenously. Sulfadiazine was the chemotherapeutic agent used. Thirty-six hours after operation a catheter was placed into the lumen of

the ileum and secured with a purse-string suture. Immediate passage of gas and fecal material through the tube was noted. Complications relative to the operative procedure itself did not appear. On the fifth postoperative day the patient complained of a severe headache which was relieved by caffeine sodium benzoate. Later he again suffered from a severe occipitofrontal headache. Examination of the fundi revealed a slight distention of the retinal veins. With the suspicion that the patient might be suffering from a virus encephalitis of which isolated cases were being seen in the area, a spinal tap was done and an initial pressure of 430 mm. was found. This was reduced but subsequent taps revealed the pressure to be still elevated. Headache was a constant complaint from this time until time of death although some relief was obtained by the repeated removal of spinal fluid. The cause of death was increased intracranial pressure due to an unknown cause with suspicion that metastasis from a tumor either of the ileum or the testis might be the responsible agent.

Post-mortem examination was done with the outstanding findings being widespread tumor masses in the retroperitoneal area. Multiple areas of metastasis were found in the lungs and the right cerebral hemisphere. A single metastasis in the spleen was found. A small tumor was found in the left testis.

Microscopic examination of these tissues revealed that the tumor in the testicle was primary and that the remaining tumors were metastatic. The testicular tumor was carcinomatous in nature with large, pale cells with vesicular nuclei. Marked pleomorphism and occasional mitoses were seen. In one section tumor tissue was seen to be invading a blood vessel. Examination of the tumor in the ileum which had been removed surgically showed an identical appearance with the testicular neoplasm. It is noteworthy that the lymph nodes in the immediate area of the tumor in the ileum did not show invasion by tumor cells.

#### SUMMARY

The case reported herein is that of a patient whose presenting complaint of an embryonal carcinoma of the left testis was the appearance of an ileocolic intussusception due to an isolated metastasis

to the ileum. Ileocolic resection was done successfully. The patient subsequently died of multiple metastases widely spread throughout the body with the immediate cause of death being respiratory failure secondary to increased intracranial pres-

sure due to a large metastatic lesion in the right cerebrum.

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WITH the exception of cases due to gas bacillus infection, acute gangrene of the scrotum is almost invariably due to the hemolytic streptococcus and, in the opinion of R. C. Robinson, ought to be treated primarily with penicillin rather than surgery. Surgery prematurely performed may be very detrimental in these acute cases. (*Richard A. Leonardo, M.D.*)

# PRIMARY TUBERCULOSIS OF THE CERVIX UTERI\*

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PRIMARY tuberculosis of the cervix uteri is difficult or impossible to prove.

In several reported cases<sup>1-6</sup> histologic examination of the tubes, ovaries and fundus of the uterus removed with or subsequent to the cervical lesion failed to reveal tuberculosis and in these instances the tuberculous infection of the cervix may be considered to be primary.

In the case we are reporting histologic study of the uterus and fallopian tubes removed five years previously did not reveal tuberculosis, and roentgenograms of the chest show no evidence of past or present pulmonary tuberculous infection. In addition to being a primary case this is the only reported one, to our knowledge, in which tuberculosis of a retained cervix has been observed several years following hysterectomy and bilateral salpingo-oophorectomy for non-tuberculous lesions.

## CASE REPORT

A thirty-four year old female was first admitted to St. Luke's Hospital on January 26, 1926, complaining of a tumor in the lower abdomen and dysmenorrhea. She had one child seven years old but had had no other pregnancies. Nothing else of importance was elicited in the history. Pelvic examination showed the cervix to be small, hard and directed downward while the uterine body was pushed to the left by a firm, fixed mass in the right fornix. The blood Wassermann was negative. The diagnosis of chronic salpingitis was made and laparotomy was performed. Both fallopian tubes were indurated, swollen, kinked and distorted by adhesions. The uterus was small and was bound to the adnexae by firm adhesions. Supravaginal hysterectomy and bilateral salpingo-oophorectomy were performed. The patient made an uneventful recovery except for a mild pyelitis and she was discharged from the hospital with a well

healed wound on the nineteenth postoperative day.

Pathologically, the specimen consisted of the body of the uterus and both tubes and ovaries. The fundus of the uterus was covered by shaggy adhesions. The cavity was small and the muscle and mucosa were somewhat hypertrophied. Both tubes and ovaries were edematous and elongated. Histologic study of the endometrium showed hyperplasia and evidences of chronic infection, the stroma being increased, moderately infiltrated and the glands dilated and filled with secretion. The uterine muscle was also slightly infiltrated and edematous. The tubes showed a late stage of chronic pyogenic suppuration; the lumina were dilated and the mucosa was very much hypertrophied and infiltrated throughout with large numbers of lymphocytes and plasma cells. There was no evidence of tuberculosis. The diagnosis was chronic endometritis and chronic salpingo-oophoritis.

The patient was re-admitted to St. Luke's Hospital on September 20, 1931, complaining of a thin, watery vaginal discharge of ten weeks duration. Several times there had been slight bleeding but during the two weeks prior to her admission there had been more constant bleeding without hemorrhages. She had lost 5 or 6 pounds in weight. Careful questioning failed to reveal any past or present tuberculosis in any member of her family and knowledge of genital tuberculosis in her husband, from whom she is now separated, was denied.

The patient was a well developed and well nourished negro. Except for the local pelvic condition no other physical abnormalities could be made out. The blood Wassermann was negative. X-rays of the chest were essentially normal. Pelvic examination showed a firm perineum which gave good support. The uterine body was missing and the vaults were shortened. The cervix was irregular and hard. On the posterior lip there was a small, friable, bleeding, fungating mass which extended upward on to the vaginal wall toward the left

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FIG. 1. Photomicrograph of primary cervical tuberculous lesion.

broad ligament. Clinically the lesion was thought to be a carcinoma.

Under general anesthesia a biopsy was taken for histologic study. Four, 10 mg. radium needles were inserted directly into the lesion and packed in place with two strips of iodoform gauze. This radium remained in place for forty-eight hours, giving a total dose of 1,920 mg. hours.

Histologic study of the biopsy specimen removed from the cervix uteri showed a portion of the squamous epithelium which was hypertrophied to a very unusual degree. The underlying fibrous stroma was converted into a mass of tuberculous tissue. There were confluent and discreet tubercles with many Langhans' giant cells, endothelial cells and lymphocytes. The diagnosis of tuberculosis of the cervix uteri was made. (Fig. 1.)

The patient was discharged from the hospital on her sixth postoperative day. At her first follow-up visit on January 26, 1932, four months after the radium treatment, she was entirely free from symptoms. The cervix was

smooth, completely healed over and showed no evidence of residual tuberculosis. The patient was seen at regular intervals and remained well until 1940 when, because of bleeding, a benign papilloma of the cervix was removed in the out-patient department. Histologic study of this benign tumor showed no evidence of tuberculosis. Bleeding ceased following removal of this polyp and the patient was symptom-free until May, 1943, when vaginal bleeding recurred and the patient lost 15 pounds in weight. Sharp curettage of the cervix yielded typical tuberculous granulation tissue. No other treatment was given and when she was last seen on September 3, 1947, sixteen years after primary treatment for the tuberculous cervix, the patient was well and free from symptoms. Examination at this time disclosed hyperemia of the vaginal mucous membrane but no ulcers or granulating areas. Histologic study of a small portion of this reddened epithelium showed only chronic vaginitis with no evidence of tuberculosis.

#### SUMMARY

A patient with tuberculosis of the uterine cervix, which occurred five years following supravaginal amputation of the uterus and bilateral salpingo-oophorectomy for non-tuberculous lesions, is alive and symptom-free sixteen years following the initial treatment with radium. This is the only reported case, to our knowledge, in which tuberculosis of a retained cervix has been observed several years after hysterectomy and bilateral salpingo-oophorectomy for non-tuberculous lesions.

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# New Instrument

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## AN OVAL-SHAPED PESSARY FOR THE CORRECTION OF PROCIDENTIA UTERI, CYSTOCELE AND RECTOCELE

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IN prolapse of the uterus the equilibrating ligamentous mechanism of the uterus and particularly the sacro-uterine and bladder uterine attachments are so attenuated or entirely detached that they allow inversion of the vault and even the whole vagina, with the varying degrees of procidentia uteri.

To relieve the procidentia non-operatively or palliatively in cases in which operation is contraindicated or refused, pessaries are used to evert the inversion. The pessary must then be of such form as to reshape or elevate the vagina without causing pressure irritation and must simultaneously have sufficient provision for drainage. It must also be a size that will withstand the pressure of straining without its protrusion or expulsion. There are several devices on the market for the purpose but from a studious observation of all of them I early came to the conclusion that the hard rubber ring pessary and usually the thick one serves the purpose best. To meet the above indication, however, this ring, in order to stay in position, has to be forced into the vagina which in most cases cannot be accomplished without causing considerable pain; the same thing is experienced on removal. Occasionally, if the ring is not removed for cleansing or inspection of the vagina for a period of several months or longer, the levator muscles and the surrounding tissues become so tonically or organically contracted as to make its removal impossible. I have encountered three such cases. The only way I was able to remove these rings after attempts at crushing them had failed was

to draw the pessary forward with a hook to expose an arc and with a thin carburandum disk attached to an electric hand drill, saw it across. The ring was then rotated to about half the distance of the severed part and the procedure repeated until it formed two separate halves. In this manner each half was easily removed.

In order to obviate the pain on insertion and removal of the ring pessary which is often associated with rupture of the superficial tissues of the vaginal outlet, and in order to prevent vaginal overstretching and to eliminate the possibility of its imprisonment, I have devised an oval-shaped pessary. (Fig. 1.) Such a pessary is about 1 cm. narrower and about 1 cm. longer than that of a ring pessary of equal peripheral measurement. As the point of insertion as well as the transverse diameter is narrower than that of a round pessary, it practically glides into the vagina. Once it is inserted, its poles turn to a slant equivalent to at least 1 cm. above and 1 cm. below spontaneously or at attempts at straining. A pessary thus fitted is equivalent to a ring pessary of an average diameter of 2 cm. larger than that of an oval one. A ring pessary of such dimension would not pass the introitus. The relatively smaller oval pessary which becomes larger in the vagina on account of its assuming an oblique position and which increases during straining will not and cannot slip out once it is properly fitted.

After inserting the pessary if it persistently stays in an upright position, that is if it does not slant to one side or the other even when attempts are made to do so, is an indication that it is too large and

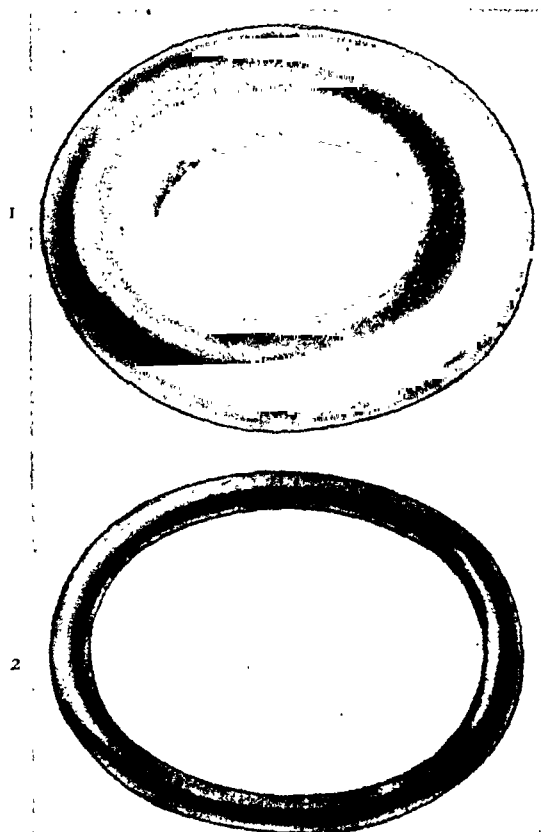


FIG. 1. A thick, hard, oval pessary. Because of its ovality, it is 1 cm. longer and 1 cm. narrower than a round pessary of the same peripheral dimension. This facilitates ease of its insertion and removal. Once inserted the poles of the long diameter turn in opposite directions, making the pessary equal or relatively larger than a round one and thus either one would be too large for vaginal penetration. Also because of its polarity deviation pressure on the cervix, the most vulnerable organ in the pelvis is, as a rule, avoided.

FIG. 2. At times a thin oval pessary will serve the same purpose as the heavier thick one. In addition it can be used when the Smith and Hodges pessaries are indicated and will often substitute them to advantage.

will cause pressure symptoms. A smaller size is indicated.

The successful accommodation of a pessary *in situ* depends largely upon the extent of separation of the levators ani and the degree of tonicity still inherent in them. The less the separation and/or the more the latent tonicity present, the more securely the pessary will be upheld. Regardless of the separation or tonicity of the levators the pessary often will assume a position of support by the vaginal outlet, the pubic rami or the symphysis pubes. It is usually in the cases in which the pessary rests on

the symphysis pubes or on the pubic rami instead of the levators that the lumen of the introitus vaginae frequently shrinks. This is due to the fact that the levators escape the direct force of strain and pressure, allowing them to undergo a process of involution culminating in their attainment of a more or less normal elastic tonicity. This is probably the type which if not duly supervised leads to pessary imprisonment. In such an eventuality or in any case in which difficulty in removal of the pessary is encountered the introital contraction or spasm can, as a rule, be overcome by slowly and gently pulling forward on the pessary from two to four minutes until the pessary is delivered. As an adjuvant measure it is wise to lubricate the outlet first.

When trying to remove the oval pessary, the finger will automatically slide into one of the narrower ends and will thus be straightened out and removed in its narrow transverse diameter without difficulty and without pain, and can be reinserted with equal ease and facility.

In the non-prolapsed uterus the thick oval pessary will, as a rule, relieve a cystocele and/or rectocele completely or in part sufficient to eliminate symptoms attributable to these conditions. When this thick pessary will not lend itself to the correction of such vaginal prolapse a thin oval one (Fig. 2) will usually meet the situation. Not infrequently in such cases a concave oval pessary will be found effective. The side to which the concavity or its convexity should advantageously face is determined by trial.

The models the author uses are home made. A hard rubber ring pessary is boiled for about 10 minutes, removed from the water, held in a towel and quickly and forcibly pressed against a hard surface covered with another towel until the desired dimensions are obtained. The pliability of the heated pessary lasts but a few seconds. If the first attempt fails, the process is repeated until the desired dimensions are secured. The plastic pessaries do not lend themselves to such pliability. They can, however, be factory or machine made.

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# The Early Art of Surgery

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## IV. THE EDWIN SMITH SURGICAL PAPYRUS

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IN case you think, when you turn on your radio, that "aspirin" is something new and of modern times, do not believe it. It is so written in the Smith Surgical Papyrus, that the surgeon of that day made a concoction of willow and wintergreen which he used externally for rubbing inflamed arthritic joints but he made a tea of the wintergreen and gave it to his patients to be taken internally. That was the salicylate of his day, in other words, his "aspirin."

This same surgeon had a wide repertoire of poultices for use in alleviating painful inflammations and for drawing pus and infectious material to the surface where it was usually allowed to rupture, thereby affecting its own healing. We probably would not care for many of his fabrications, speaking esthetically, because they consisted of working up the dung of different animals into either a smooth or stiff paste, heating this mixture, spreading it on lint and then applying it to the part.

Evidence proves that he was a shrewd, discerning observer, a bit puzzled perhaps as to the why but describing fairly accurately what he was looking at. He told of a skin enveloping the brain; but since he had no word for brain, he conjured up a word picture which served the purpose. The brain convolutions, therefore, he described as like "molten metal settling in a ladle." He noticed changes of speech after certain skull fractures and explained that this occurs always when the blow is in a certain area. In some who survived very severe skull injuries he noted that forever

after they walked with a shuffling gait. In these cases of blows to the head and skull fractures, of which he saw many, he put in his notes about how often the foot or hand or both are paralyzed on the side opposite to that of the injury, and how often the eye is ptozed on the same side as the injury.

He took the pulse, "in order to know the action of the heart," and told of the various places where the pulse can be taken other than at the wrist.

The method of procedure of a surgeon, when called to a case, probably set the pattern of our own procedure today: First, he obtained a history either by direct questioning of the patient, if he were conscious, or from relatives or friends, if the patient were unconscious. Second, he observed the patient by means of his ocular, olfactory and tactile senses. Upon completion of his examination he made his diagnosis which slanted a bit toward what we today would call prognosis. He used linen and lint to make plugs, tampons and compresses. Bandages he obtained either from the most skillful embalmer of all time—any Egyptian embalmer—or he called in the latter to help. He had adhesive plaster for bringing together a gaping wound. For more extensive wounds he used sutures. "In this papyrus is the first recorded instance in the history of surgery of actually sewing up a wound." The directions for suturing as given in the papyrus are as follows: "Thou shouldst draw together for him his gash with stitching." Edges of wounds were usually brought together with adhesive plaster, "in order to join one to



the other." In some cases he used both stitching and adhesive plaster.

He had a variety of splints. For instruments he used a needle and a "fire drill" for cauterization. Probing was done with the fingers, never with an instrument. In some of our American Museums and in many on the continent specimens of lancets and scalpels can be seen. Almost all are made of bronze and they come in a wide variety of sizes and shapes.

The Egyptian surgeons apparently were extremely adept in the handling of fractures, as the bones of ancient skeletons show excellent alignment and union and rarely any deformity. In an article on this subject written about fifty years ago by an English medical archeologist he calls attention to the fact that obviously the manner in which these fractures were produced would certainly predispose to a large number of compound and comminuted fractures, yet in all his experience he had seen only one skeleton in which there was any evidence that suppuration had occurred. (Fig. 1.)

There is no evidence that the Egyptian surgeons practiced trephining as is commonly believed. Their treatment of fractures of the skull was that of "laissez faire," but for some reason these patients were not placed in a reclining position. They sat up straight and a mould or cast of their body was made of clay or earth, coming up under the arms for support. This was allowed to harden and form a good plaster jacket. The Egyptian usually applied poultices of raw meat particularly after reduction of a fracture to lessen swelling and ease pain. Beef-steak for a "black eye" had its origin here—without question.

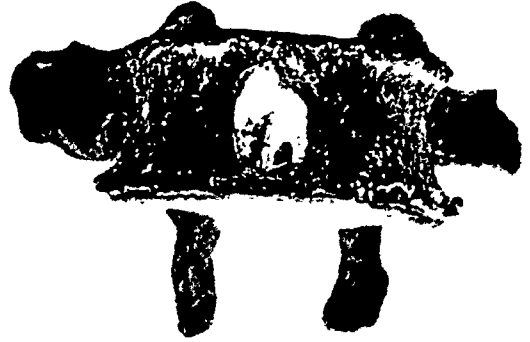


FIG. 1. Pott's disease of spine; taken from J. H. Breasted's "The Edwin Smith Surgical Papyrus."

The surgeons of those days evidently liked to present their good results in much the same manner as we moderns, because we find in one illustrative figure the skull of a man across which run several linear fractures in many directions, then there is a plate showing the healing of these fractures with very little scar and a note that the man survived.

From the bibliographical angle, the papyrus originally consisted of twenty-one complete columns. In the original deal between one Mustapha Aga and Mr. Smith, seventeen fragments were held back by the seller because he did not want to mar things up with appendages et cetera, which might give the buyer the impression that he was not getting a complete and perfect manuscript as it was supposed to be.

The illustrations used here are taken from Breasted's masterly and scholarly work on the papyrus, a work which will probably never be surpassed because of its infinite painstaking attention to minor detail, not overlooking that it is also a translation which few men are mentally equipped to accomplish successfully.



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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-eighth Year of Publication

VOL. LXXVIII

SEPTEMBER, 1949

NUMBER THREE

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## Editorial

### TEAMWORK IN SURGERY

**T**EAMWORK is a word denoting real efficiency in any line of work. In medical diagnosis it is an essential yet the literature seems to be wholly lacking in material directly on the subject of teamwork in surgery.

By surgical teamwork I mean the working together of two responsible surgeons automatically doing the things most suited for each or within better reach of one or the other, assisting one another at critical points or working in order to get hands and instruments out of each other's way.

Teamwork saves time in surgery. There is economy of material in the process consisting of the saving in anesthetic material and stimulating adjuncts necessary in longer operations.

The patient benefits from the proposed teamwork because there is less trauma in a shorter operation. There is more efficiency in having two experts instead of one with a less trained assistant. There are less chances for mistakes because the eyes of both take in the entire field, for each surgeon is watching constantly for the opportunity to act independently or to cooperate at the right moment. The anesthetic is invariably shorter by at least one-fourth, a great advantage in extensive surgical procedures such as gastric resections. There is less shock from the anesthetic than would otherwise be the case and less time for

hidden or unrecognized bleeding. Therefore, there is a smaller mortality rate.

Our personal experience has borne out these statements. We have performed several types of major operations from start to finish with a proven saving in time. It is true that there are individual surgical experts who claim a comparatively short working time involved but in such instances the closure is usually left to assistants who unnecessarily take longer time to finish, making the total time longer than justified.

Teamwork gives the patient a better chance when surgery is necessary and less chance to have unnecessary surgery done. The ideas of more than one mind provide a better selection in the type of procedure to use. It gives younger, capable surgeons a chance to show their skill and develop their art still further instead of being held in an inferior status by a dominating chief surgeon. The requirements of charting are easily taken care of by one or the other taking the lead in starting. Thus the operator can be designated on the chart as the surgeon, or it can be the one to whom the patient has assigned the responsibility. I see no reason, however, why it cannot become customary to add an "s" to the word surgeon on the operative record when two are working together as a team. When either of two surgeons can take the lead in

making the incision, the patient will have less chance of a wait between the time of being ready from the standpoint of the anesthesia and the start of the operation. In the case of the single chief surgeon it has often happened that the anesthetized patient has had to wait because the surgeon was uncontrollably delayed in starting. Therefore, the presence of a pair of skilled surgeons should also make it safer for the patient in case anything unexpected happens to incapacitate or delay one or the other.

This teamwork resulting in improved

service may in some measure improve public relationship, the fostering of which is so necessary in the progress of the American way of practicing medicine. It may be thought impossible to achieve this ideal relationship between two surgeons but to deny the possibility, especially in larger centers, is to admit failure in our training program. The long-equalized surgical training of our modern day certainly should produce surgeons who can work together, especially if they have this teamwork idea in mind during their training.

REGNER W. KULLBERG, M. D.



*Correction:* It was H. L. Menken, if we are not mistaken, who wrote that a galley proof or page proof could be gone over with a fine-tooth comb by a dozen experienced proof readers, and at the final printing a glaring boner would hit the average reader right between the eyes. This happened in the July issue of this Journal. Dr. Philip Thorek wrote a splendid article entitled "The Fallacy of the So-called Thyroid Capsule." It should have gone in the body of the Journal. But lo and behold! when we received our copy of the July number and glanced through it, there was Dr. Thorek's article under the heading, in large type, "New Instruments." We felt badly about this error, and we learn the gloom was deep and prolonged among the personnel of the editorial office when we told them to look at page 133 of the July issue, and frame up an answer for "How come?"

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# Original Articles

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## WEDGE OSTEOTOMY OF THE NECK OF THE FEMUR IN ADVANCED CASES OF DISPLACED UPPER FEMORAL EPIPHYSIS\*

### TEN-YEAR STUDY

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THE subject of slipped capital femoral epiphysis and its treatment has been widely discussed and often reviewed over the past twenty years. A survey of the literature throughout this period is interesting in that the concept of treatment of the severely slipped epiphysis has gradually evolved as the end results of the newer methods have been studied and compared. Key<sup>9</sup> states that one of the early German authors, Hofmeister, noted that he had seen the symptoms of the acute stage subside without any treatment whatever and, after a variable period of time, the function of the involved hip improve. The early idea of treatment was apparently to protect the extremity by means of a splint; later plaster immobilization was employed. In 1897 great hope was placed in manipulation with plaster immobilization as used by Royal Whitman.<sup>19</sup> The open reduction procedure was publicized by Whitman in 1909<sup>20</sup> but it was soon noted that the results of these treatments left much to be desired. As Key pointed out, the results of cases in which patients were so treated proved to be poorer than the results of those left untreated or treated simply by splints. Open reduction followed by plaster immobilization was advocated by Wilson<sup>22</sup> also but the results were still reported as rather poor. With the advent of the Smith-Petersen nail, open reduction

which amounted to reposition of the head on the neck, became the treatment of choice. The results were much better than those of any preceding method of treatment but there were still a number of patients in whom symptoms developed or who were left with marked restriction of motion. The subtrochanteric osteotomy and the wedge osteotomy of the neck of the femur followed. The latter form of treatment, the subject of this study, had been used sporadically but it has been only in recent years that it has gained attention.

Over recent years the conservative treatment, consisting of manipulative reduction followed by plaster immobilization, has been largely superseded by internal fixation. In most quarters this has been accepted as the treatment of choice in cases of early or minimal slipping. The great problem has been, and still is, which form of treatment is most efficacious in handling those cases in which there is a slipping of more than one-third the diameter of the femoral neck at the site of the epiphysis. Restitution of the normal alignment of the head and neck of the femur must be obtained in order to insure a good, functioning hip.

### PATHOLOGY

A study of the pathology of the severely slipped epiphysis will clarify the necessity

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for reposition of the displaced head. In 1926 Key reviewed the subject extensively and, in a complete study of the pathology of twenty-four cases in the German literature, he described accurately the pathologic anatomy: When the slipping first occurs, it is noted that the head moves downward and the cartilage covering the upper part of the head and the adjacent periosteum is stretched, a tear finally occurring at the border of the cartilage. As the head slips down, the leg rotates out and, with the head fixed in the acetabulum, it moves backward upon the neck with torsion of the head in some cases. The head assumes the attitude of flexion and the femur moves in the direction of extension. As the head moves down and back, it rotates upon the lower and posterior border of the end of the neck, which sinks into the cancellous tissue of the head. The projecting lower and posterior borders of the head approach the corresponding surfaces of the neck. The upper and anterior portion of the mesial end of the neck, laid bare by the departing head, becomes covered with fibrous tissue and this serves to extend the anterior and upper surfaces of the neck. These surfaces become rounded off with remodelling of the acetabulum with which they are in contact. This along with the upper and anterior portion of the head form a new articular surface of the femur. Next a remodelling of the acetabulum takes place to accommodate the new articular surface. The overhanging lower portion of the head tends to disappear and the head becomes sickle-shaped. There is also a thickening of compact bone along the lower border of the neck to meet the increased strain due to the lessened mechanical efficiency of the neck. The pelvis also eventually becomes deformed on the affected side. The final result is a thick neck, with a short, curved lower and posterior border and a long, convex upper and anterior border capped by a deformed head. The neck is bent downward and back with a collodiaphyseal angle of 90 degrees. The neck is bowed upward and anterior; and on its elongated

upper and anterior borders at about the junction of the middle and inner third, a bony prominence is formed at the original points of attachment of the upper and anterior borders of the head. Many cases of *malum coxae senilis* probably represent late cases of slipped epiphysis.

Howorth<sup>8</sup> has given a good review of the pathologic changes observed in cases seen at different stages of slipping. He also describes the layer of firm fibrous or cartilaginous tissue covering the exposed portion of the end of the neck. He notes that although the disturbance in the alignment of the head and the neck can be seen, no separation is detected between the head and the neck.

Similar pathologic occurrences were observed in patients treated by the open method in the operating room at the Hospital for Ruptured and Crippled, the outstanding feature being that no sharp line of demarcation could be discerned between the slipped head and the neck. At the point of greatest deformity on the anterior and superior aspect of the junction of the head and neck, there was noted quite a marked proliferation of soft fibrocartilage of a rather greyish blue color. This knuckle-like protuberance gave the appearance or illusion that the neck had bent like a soft tallow candle rather than that the head had actually slipped on the neck. In many cases it was noted that there were fibrous adhesions between the capsule and this fibrocartilaginous portion of the neck.

Observing the deformity at the time of operation and also that seen in the anteroposterior and lateral x-ray films, it is readily apparent that in these cases of marked slipping the normal mechanics of the hip joint are disturbed. The head is thrown downward and posterior, which easily accounts for the attitude of external rotation and limitation of flexion, internal rotation and abduction. This limitation is marked; in the extreme range of these motions the fibrocartilaginous knuckle previously described impinges against the acetabulum. It is believed that this me-

chanical impingement is a source of chronic irritation and, if neglected, will ultimately result in the development of degenerative arthritis.

It is true that much of the limitation of motion observed in cases of slipped epiphysis is due to the muscle spasm as pointed out by Moore.<sup>14</sup> However, this will subside with bed rest or immobilization alone. In cases of minimal slipping there will be, to all practical purposes, no detectable differences in the range of motion of the good or of the involved hip; whereas, in cases of more advanced disorders there will be a mechanical limitation of motion persisting and chronic after the acute stage has subsided.

#### METHODS OF TREATMENT

1. *Manipulation.* The proper treatment of patients with advanced slipping has been a controversial subject for some time although all programs aim at reduction of deformity. It is quite certain that without treatment degenerative changes in the joint will develop later in patients with marked slipping. Ghormley and Fairchild<sup>6</sup> brought this out in a presentation of nine cases of adults who had been treated conservatively for symptoms due to old slipping of the epiphysis. At the final summation they complained of pain on motion of the hips, limitation of flexion, internal rotation and abduction along with a permanent external rotation deformity. X-rays revealed evidences of osteo-arthritis of the joint margins with sclerosis of the acetabulum and head of the femur.

Perhaps the earliest attempts at correction of this disability were through closed reduction either by manipulation or strong traction. In a review of patients treated by manipulation at the Massachusetts General Hospital from 1904 to 1923, Key stated that he could not consider any of the results good. Seven patients so treated had, at the time of manipulation, been put through a complete range of motion in flexion, internal rotation and abduction but the epiphysis could not be replaced

in a single instance. Although the acute symptoms always quieted down and there was freedom from pain except with exercises, follow-up revealed a marked limitation of motion and even ankylosis in some cases. X-rays revealed the head to be enlarged and flattened, resembling an old Perthes' disease. There were also signs of hypertrophic arthritis.

Klein<sup>10</sup> followed up this series of cases at the Massachusetts General Hospital from 1924 to 1932 and, just as Key had observed earlier, found the results poor in all the patients treated by manipulation.

Badgley<sup>1</sup> in 1929 reported on the results in the manipulation of eighteen patients, with good results in nine. He qualified this statement, however, by saying that motion might be limited beyond 90 degrees and accompanied by slight limitation of internal rotation. The nine patients showing good results were manipulated within six weeks after the onset of symptoms, while the nine patients whose results were rather poor were treated four months after the onset of symptoms.

Wardle<sup>18</sup> also reported poor results in 1933 with the method of manipulation. In his paper he clearly illustrates by diagram the manner in which the joint is damaged in manipulation with abduction. With the femur abducted, the lower edge of the metaphysis engages the separated epiphysal surface and tends to force the epiphysis farther down and backward in the acetabulum. Any leverage used to effect reduction has a fulcrum action at the point where the articular cartilage of the head impinges on the lower posterior acetabular margin, resulting in bruising of the cartilage and subsequent arthritis. Also, the metaphyseal edge ploughs through the cervical surface of the epiphysis and the interior posterior margin of the head tears the posterior portion of the capsule. The ligamentus teres is also ruptured.

Sixteen patients treated by Wilson were followed up. In 1936<sup>23</sup> he noted that the deformity was rarely corrected by manipulation. Postmanipulation films are prone to

deceive inasmuch as a film taken in extreme internal rotation, as Waldenstrom<sup>17</sup> later pointed out, would give the illusion that the deformity was corrected because of the superimposition of the head on the neck. Wilson attributed the degenerative changes to interference with the blood supply, the cervical vessels across the epiphyseal line usually having been ruptured at the time of the pathologic process with the only remaining blood supply lying in the ligamentum teres and this last having been ruptured or seriously compromised at the time of manipulation.

Twenty-five per cent of the patients treated by manipulation were reported by McMurray<sup>13</sup> in 1938 to have developed a marked rigidity of the joint which he attributed to injury to the surrounding soft tissues and interference with the blood supply to the head. Waldenstrom observed that in one-fifth of all the joints treated by manipulation the function of the joint was destroyed by necrosis of the head.

In a review of the patients treated at the Mayo Clinic over a period of fifteen years Ghormley and Fairchild reported in 1940 that of eight patients treated by manipulation there were six good results, one fair and one poor. The six patients showing good results were manipulated fairly early after the onset of symptoms, the duration being from two to nine months. The patient whose result was poor had had symptoms over two months with complete slipping.

Howorth reviewed twenty-one cases of patients treated by manipulation, in three of which partial reduction was accomplished. These patients were manipulated shortly after slipping and there was no callus in the inferior angle of the head and neck. The results were very discouraging; it was a study revealing permanent limitation of motion with occasional circulatory changes.

End results of the conservative treatment of slipped epiphysis were reported in eleven cases by Forrester-Brown in 1941.<sup>5</sup> The Leadbetter method was used, fol-

lowed by a plaster spica which was used as a walking plaster until healing had taken place across the epiphyseal line. Following this treatment all patients walked with a normal attitude and without an apparent limp; all had full extension and internal rotation to the neutral position; all had limitation of flexion but were able to sit comfortably; only one patient had internal rotation beyond the neutral position; in nine patients there was limitation of abduction and adduction and external rotation; only one patient had a full range of motion in all directions.

Green<sup>7</sup> in reporting on the results of various means of treatment of this deformity stated that closed reduction with spica fixation had produced poor results in all cases.

After analyzing these results from various clinics and with a good understanding of the underlying disorder, it is difficult to appreciate the hope for success with manipulation in any case except that in which the slipping has been acute and very recent. It is hard to see how manipulation could hope to correct a deformity which appears quite solid when viewed grossly in the operating room and which is associated with marked callus formation both on the anterior lateral aspect and on the inferior angle of the head and neck. Furthermore, it would seem almost impossible to obtain the necessary fixation of the short proximal fragment, consisting of the head and proximal portion of the epiphyseal plate, in order to bring the distal fragment into proper alignment by applying the necessary force. One is confronted with essentially the same problem in the recently slipped cases and, as Wardle points out with good mechanical reasoning, one should be very reluctant to use forceful manipulation, especially accompanied by forced abduction, for fear of damaging the head or the articular cartilage and tearing the capsule and ligamentum teres.

2. *Manipulation by Traction.* Manipulation by the use of traction has been the preferred treatment in some clinics for ad-

vanced cases. Wardle reported favorable results by the use of a Jones spinal frame which maintained traction and corrected the external rotation deformity, continuing the use of extension until follow-up x-rays revealed correction of alignment. As previously mentioned, Wardle emphasized the dangers implicit in attempts at abduction of the hip.

Forrester-Brown treated some patients by traction alone, amounting to 15 or 20 pounds. The follow-up in which complications and sequellae were not mentioned was unsatisfactory but the statement was made that x-ray results of all these cases were poor.

In Howorth's review he mentioned seven patients who were treated by traction and immobilization in plaster in the attitude of internal rotation and abduction. Strong traction was utilized and in most of the cases the deformity was corrected. Results, however, were discouraging in that in only one hip the result was called good and in one fair. In most instances the heads became irregular and the joint space thin. The author attributed this to the stretching of the capsule with circulatory disturbance of the head.

Green in 1945 reported on a series of thirteen patients treated by what he terms the "traction-spica-traction" method. He used this method in patients with more than 0.8 cm. displacement of the head. The treatment consisted of traction in which gradual internal rotation and abduction were maintained until the deformity was corrected, at which time the patient was put up in a spica for a few months to hold the correction. Traction was again utilized after the fixation was discontinued to aid in the mobilization of the joint. Green reported the thirteen patients so treated showed good results.

3. *Open Reduction.* Of the surgical methods for the correction of the deformity at this advanced stage there are three that have been used rather extensively to the present time. They are open reduction with reposition of the head, subtrochanteric

osteotomy and wedge osteotomy through the femoral neck.

*Open Reduction with Reposition of the Head.* Follow-up studies of patients treated by open reduction with reposition of the head, although the proportion of failures has been high, have nonetheless revealed many good results. In 1936 Kleinberg and Buchman<sup>11</sup> reported five patients treated by removal of the epiphyseal plate with direct contact of the cancellous bone of the head and neck of the femur securely fixed by a bone peg. They stated that the operation had been used in all five cases with uniformly good results.

Howorth reported on seventeen patients in whom open reduction was performed through the epiphyseal plate. Of these patients, eleven were immobilized in plaster for a period of ten to twelve weeks. A follow-up covering two and a half to seven years revealed only two good results with two complete failures. Six of the patients were immobilized by means of internal fixation and allowed motion within the first week. Of these patients, two showed good results, three fair and one poor. These patients also had a higher index of motion than the former group. Howorth believed that the plaster immobilization tended to produce these poor results because of the acute synovitis present which would cause limitation of motion. He stressed the point that if there were a great deal of limitation of motion due, probably, to muscle spasm, the operation should be preceded by bed rest with light traction.

Klein reviewed thirty-nine patients with femoral epiphyses treated at the Massachusetts General Hospital from 1924 to 1932 by open reduction. He found poor results followed open reduction with plaster immobilization; better results were obtained when open reduction was followed by internal fixation. Eleven patients who had been treated by arthrotomy and reposition of the head with internal fixation were followed sixty-four months, with an average index of motion (as devised by Ferguson and Howorth<sup>4</sup>) of two-thirds nor-



mal. Only three patients had pain and this was of a minor nature; three had a severe limp. The average percentage of normal hip function was 71 per cent by his method of rating, whereas the function obtained in hips in which a minimal slipping was merely nailed was 94 per cent of normal. In view of the results the authors recommended this mode of treatment.

In a recent review of eighty-seven cases with a five to fourteen year follow-up Moore stated that the rate of aseptic necrosis had been 13 per cent, with 50 per cent of the results poor. Badgley<sup>2</sup> reviewed the results of all forms of treatment followed in his clinic. Of a total of forty-nine patients treated by open reduction, eleven had been immobilized by plaster and thirty-eight held by internal fixation. Of the first group he reported four excellent results, two good and five poor results; of the second group, twenty-one patients showed excellent results, four good, one fair and twelve poor. He further analyzed these cases and attributed the poor results to aseptic necrosis in one instance, non-union of the osteotomy site in another and, in the remainder, to evidence of traumatic arthritis.

*Subtrochanteric Osteotomy:* The literature reporting treatment of these advanced cases by subtrochanteric osteotomy is not extensive. Howorth reported in 1941 six patients so treated with fair results in all. He reserved this procedure for those patients in whom the deformity caused impingement of the neck on the acetabulum. He also stressed the importance of waiting until the acute nature of the diseased process had subsided, for the necessary plaster immobilization during the stage of acute synovitis will cause considerable limitation of motion.

In Klein's series of cases reported in 1943 the three patients in whom subtrochanteric osteotomy was performed were called the poorest of the entire series. All had marked limp and pain and two had no motion at all. The total percentage of normal hip function as graded by Klein was

from 0 to 35 per cent of normal with an average of 22.8 per cent.

Badgley in his paper had four patients who were treated by subtrochanteric osteotomy. Two of these he classed as excellent, one good and one poor. These results were very satisfactory in that the patients selected for treatment by this means were those in whom there was obliteration of the epiphysis.

*Wedge Osteotomy:* In dealing with these cases of marked slipping of the epiphysis, the wedge osteotomy, in which a cuneiform section of bone is removed from the femoral neck just distal to the epiphyseal plate, seems to be the most anatomically and mechanically sound procedure. This form of treatment ideally performed corrects the deformity and accomplishes reposition of the femoral head upon the neck.

Balensweig<sup>3</sup> presented two of the earliest cases in which the patients were so treated. One was operated upon in 1908 and the other in 1910 at the Hospital for Ruptured and Crippled. The result of the first case was poor due to a mushrooming of the head and obliteration of the joint space. The second also had some mushrooming but the joint space was preserved.

Eleven patients treated by wedge osteotomy were followed for a period of from one to eleven years by Ghormly and Fairchild with six good results, three fair, one poor and one unknown. Internal fixation of some form was used in all these cases.

Included in the group of patients treated by open reduction by Howorth were six in whom osteotomies through the neck were performed. Fair results were reported in all of them.

In Green's series of cases reported in 1945 there were four patients treated by means of open reduction with skeletal fixation. This operation consisted of stripping the periosteum from the neck and separating the epiphysis if fresh. An osteotomy through the neck was done if healing was taking place. This open method was used on patients with more than 1.5 cm. of slipping. He reported one excellent

result, one good and one poor; one was too recent to grade.

Badgley included in the group of patients treated by various means a report of 34 hips treated by wedge osteotomy of the neck of the femur. The follow-up period was not stated. Excellent results were reported in nineteen of the cases; three were reported good, one fair and eleven poor. The complications listed were aseptic necrosis in one case, non-union of the epiphysis in one and degenerative arthritis in ten.

Martin<sup>12</sup> in an unpublished paper reported on eight patients treated by wedge osteotomy. Of these, six were classified as excellent functionally although one did develop a small area of aseptic necrosis with an incongruity of the head in this region. There was one very poor result which the author attributed to the fact that during the operative procedure the nail penetrated the head and went into the cartilage of the acetabulum. Of the eight patients, one was too recent to follow up. The remaining seven have been followed for an average of twenty-one months, the oldest thirty-nine months, the most recent ten months. The author made a great point of the technical procedure in that the periosteum of the neck is carefully elevated and the osteotomy performed within the periosteal tube without disturbing the periosteum and retinaculum on the posterior aspect of the neck of the femur. An additional feature of his technic is the insertion of the Smith-Petersen nail over a previously placed guide wire.

#### OPERATIVE TECHNIC

The success of the wedge osteotomy depends largely on the proper selection of the type of case for which the procedure will offer improvement. There have been three criteria established for this determination: first, the epiphyseal plate must still be open; second, there must be a good portion of neck present with the deformity not so severe that there is no neck to work with; third, there must be absence of x-ray evidence of degenerative arthritis.

The first requirement, that of an open epiphyseal plate, is insisted upon for it is believed that with the plate still open the blood supply is adequate for healing and there is less likelihood for the development of an aseptic necrosis. Once the plate is closed, it is known that the vessels in the posterior-inferior retinaculum become smaller and tend to disappear.

The second point is self-explanatory. If the deformity has gone on to such an extent that the entire neck is involved, as is frequently seen in cases of long standing, there is no room to perform the osteotomy.

An absence of degenerative changes in the x-ray is insisted upon for there is not much to gain from surgery on a hip which will have symptoms persisting from arthritic changes even when the mechanics have been corrected.

Of equal importance for the success of this procedure is the proper technical execution of the operation. It is very important not to disturb an already compromised blood supply to the femoral head. The osteotomy must be performed just distal to the epiphyseal plate but should still be done through the bony part of the neck. If correction of the deformity were attempted by division at the epiphyseal plate, trauma might be added to an already impaired circulation of the head, whereas the neck of the femur has an ample circulation and, by removing a portion of the cancellous bone, one does not disturb the circulation of the impaired epiphyseal plate. To reduce the deformity mechanically, it is necessary to remove an adequate wedge of bone, 1 to 1½ cm. in width with base anterior and superior so as to give adequate correction in two planes. A pre-operative study of the x-rays, both antero-posterior and lateral, will indicate where most of the correction should be taken. The epiphyseal plate should be accurately located which is sometimes difficult with the marked proliferation of fibrocartilage over the deformity of the neck.

In obtaining exposure of the neck the capsule is incised longitudinally and supe-

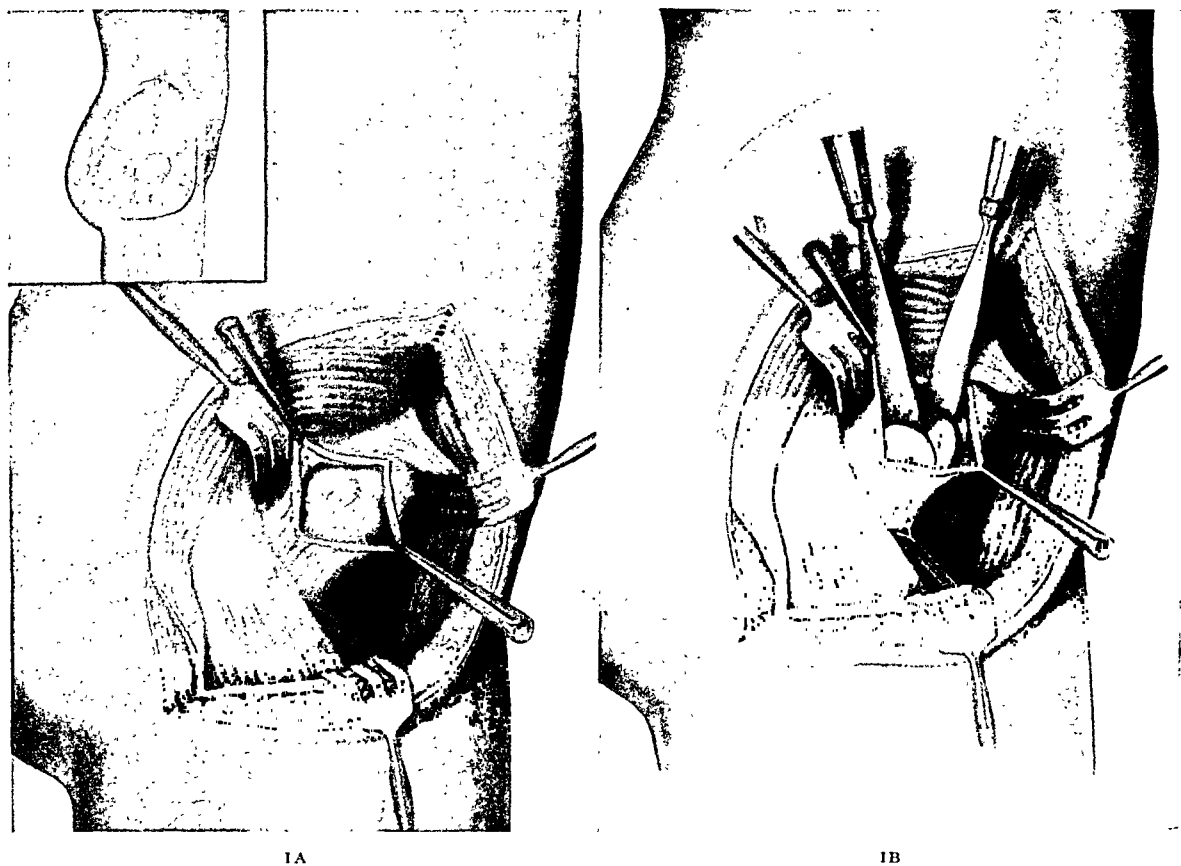


FIG. 1A, operative approach; B, division of the neck of the femur.

riorly over the neck and retracted with as little trauma as possible without disturbing needlessly any of the blood supply. (Fig. 1A.) It is very important in doing the osteotomy to make the most proximal cut first; otherwise it would be exceedingly difficult to do an osteotomy on the very short fragment of femoral head and neck (Fig. 1B, C and D.) In placing the nail one of the difficulties has been to get satisfactory penetration of the head. With impaction, distraction and separation of the fragments must be guarded against.

Postoperatively, the hip is immobilized in a plaster spica for a period of two weeks. The hip is kept in a neutral position to guard against a deformity of external rotation. After the plaster is removed, the patient is allowed up on crutches with a lift under the opposite shoe. He is then given active exercises and motion in the hip joint is restored. The patient is ambulatory and kept on crutches with a lift

under the opposite shoe for a period of nine months to a year. When there is evidence of good union at the osteotomy site and epiphyseal junction and if there are no signs of circulatory disturbance to the femoral head, the patient is allowed full weight-bearing. However, return to completely unrestricted activities is not allowed for another year. This includes competitive sports such as baseball and football in which boys, especially of this age group, would indulge.

#### END RESULTS

Twenty wedge osteotomies have been performed since 1938 on the senior author's (L. C. W.) service for those cases of slipped epiphysis of a degree so marked that some correction of the alignment of the deformity was required. All but one of the twenty patients in whom one-third or more of the femoral heads were displaced, have been followed over a period of at

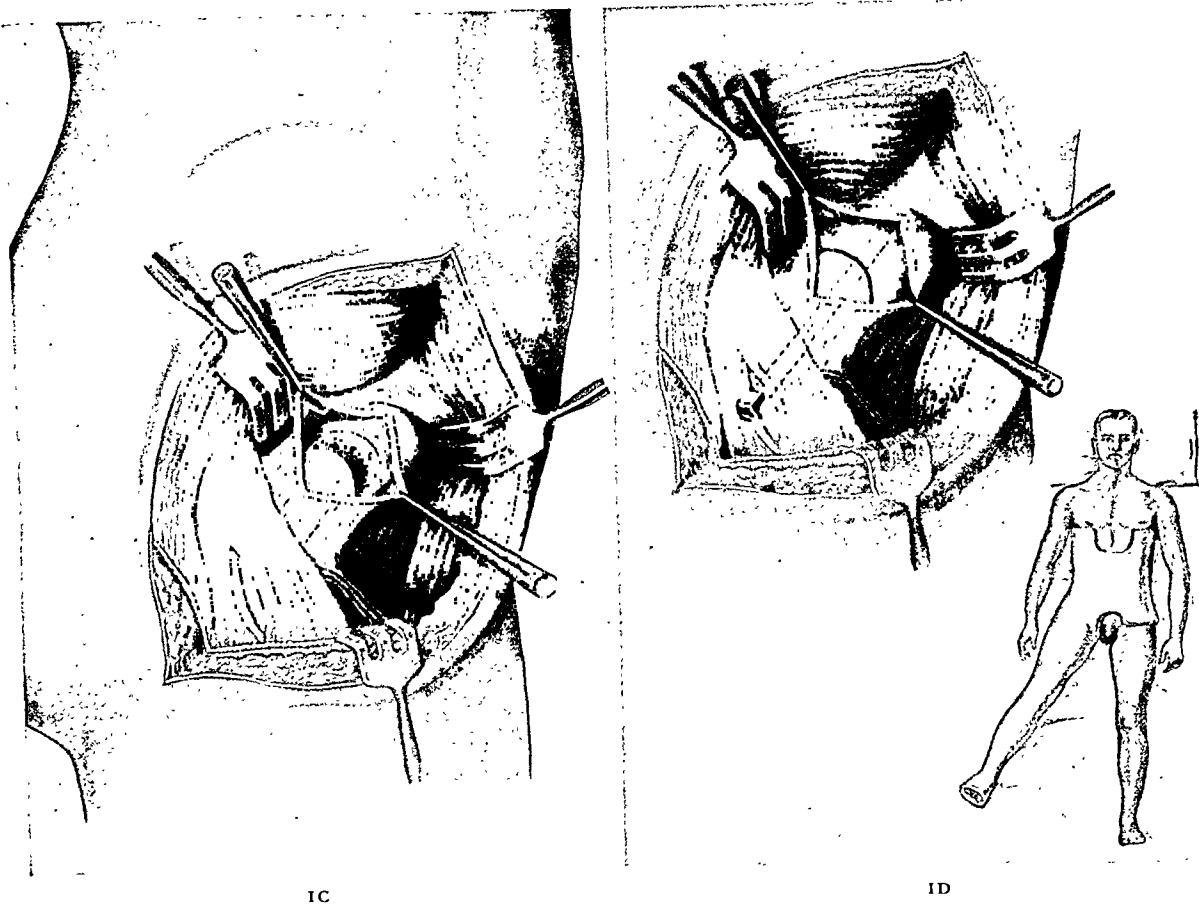


FIG. 1. C, removal of the wedge from the neck of the femur; D, closure of the defect, correction of the deformity and fixation of the fragments.

least one year. The longest has been followed for nine years and the most recent for just one year. One of the cases is too recent to report. The average length of follow-up is three years and four months. There are eleven cases which have been followed over three years and five cases followed over six years. Fourteen patients are male and six female. The average age is thirteen years and three months: the oldest patient was fifteen years of age at the time he was seen, with three patients at this age; the youngest patient was eleven years of age when first seen, with two patients at this age.

Bilateral slipping had occurred in six of the patients; in three of these the second hip slipped after the wedge osteotomy and was picked up fairly early. It was merely fixed by means of a Smith-Petersen nail. In these three cases the range of motion in

the hip with the osteotomy was better than or equal to the hip nailed. In two cases the opposite hip was not treated but the slippings were discovered upon follow-up x-ray examination. In the sixth case there were already degenerative arthritic changes of the unoperated hip and it was planned to do a subtrochanteric osteotomy after the patient had the wedge osteotomy for a year.

An analysis of the symptoms in all cases reveals a definite history of antecedent trauma in fourteen of the cases. As far as duration of symptoms is concerned, the average period of time was ten months; the shortest was two weeks and the longest two and a half years. The average duration of symptoms with a history of trauma was seven months; without trauma the duration was ten months. Thirteen patients were noted to be obese at the time of ad-

mission; only four, three of whom are still in their early teens, were obese when last seen at the follow-up examination.

All patients on their return were examined by the same person. It was determined whether or not the patient presented any symptoms referable to the involved hip, whether he walked with or without a limp. The leg lengths were measured, the range of motion of both hips carefully noted and the anteroposterior and lateral x-rays of both hips as well as clinical photographs in the various ranges of motion were obtained. These were the criteria in rating the cases, each case being judged excellent, good, fair or poor.

Excellent includes the cases in which there were no symptoms. The range of motion was normal or presented less than 20 degrees limitation in flexion and 10 degrees in internal rotation as compared with the opposite hip. The x-rays presented no evidence of aseptic necrosis or degenerative arthritis.

Good includes these symptomless cases in which the limitation of flexion and internal rotation was greater than previously noted; but not more than 90 degrees was possible in flexion, with limitation of internal rotation less than 10 degrees. There was no x-ray evidence of pathologic changes in this group.

Fair is the rating given those cases without symptoms which presented flexion only to 90 degrees or a little less, with no loss of internal rotation beyond the neutral position and no x-ray changes.

Poor includes cases in which there was a marked limitation of motion with flexion less than 90 degrees and no rotation, or rotation limited to a very few degrees. Symptoms were present in this group including pain, limp or fatigue and/or x-ray evidence of degenerative changes.

The twenty cases done in the past nine years thus are graded as follows: excellent twelve, good three, fair one and poor three.

The three cases rated poor have been studied in an attempt to determine, if possible, the factors governing their outcome.

One of these patients, S. G., at this time has a very marked limitation of range of motion as shown on the graphic charts. X-ray examination of the hip reveals some enlargement and irregularity of the head; however, the cartilage is not thinned and there is good joint space. This patient has no symptoms referable to the involved hip, with the exception of a limp which is due to the limitation of motion and a shortening of  $1\frac{1}{2}$  inches, the most marked degree of shortening encountered in this series. This may be explained by the fact that the patient, operated upon at the age of thirteen years, has reached the height of 6 feet 5 inches and must have grown considerably since the proximal femoral epiphysis was fused. The limitation of motion may be attributed to the fact that at the time of operation the nail apparently was driven through the articular cartilage of both the head and the acetabulum. This condition prevailed for a period of eleven months. It is interesting to note that the day before the patient came in for an end result study, he had cycled twenty miles. One could say that although he had a poor result as far as motion is concerned, he has a functional, painless hip.

Another end result rated as poor is that of A. C. In addition to marked limitation of motion in all directions as shown on the charts, he also has symptoms consisting of a slight limp and an occasional episode of pain in the knee which he definitely associates with strenuous activities and weather changes. It is not constant, however, and the boy enjoys full activities. X-ray examination at this time reveals a narrowing of the joint space, enlargement of the femoral head and lipping at the head and neck. This along with the presence of sclerosis in the acetabulum indicates degenerative arthritic changes. There are also areas of increased and decreased density which are highly indicative of aseptic necrosis although there is no crushing of the head. The osteophytic deposits at the margins of the articular surface probably cause some of the limitation

of motion. There are two factors which may account for this poor result: First, at the time of operation a considerable increase in the synovial fluid was noted. Howorth brings out the point that operation with subsequent immobilization should be avoided in cases in which acute synovitis is present because limitation of motion is a common sequella. Second, a factor to consider in this case is that at the time of operation it was noted that as the nail was being inserted the head of the femur was rotated anteriorly with a resultant defect posteriorly. This may have compromised the blood supply and contributed to aseptic necrosis.

The third poor result is that of M. A. She also had a considerable limitation of motion although not as much as the preceding two cases. Her symptoms include a slight limp, especially when tired, and also occasional pain in the right hip and knee at night after indulging in strenuous activities. These symptoms are also associated with weather changes. This case is one which had been neglected for a long time after the onset of symptoms which were preceded by trauma and which persisted for one and a half years before hospital admission. This, however, is not the chief factor for we have other cases, those of N. F. and V. P., in which the symptoms, also associated with trauma, were present for one and a half years. The x-rays show some residual deformity consisting of a backward tilt which may be, in part, cause for limitation of motion. There is not, at this time, any evidence of degenerative arthritis. At the time of operation the defect at the site of the osteotomy did not close completely and a fragment of bone was so placed as to fill up the gap. Another contributing factor in the causation of symptoms may be her obesity, as this patient weighs 185 pounds.

The one case rated as fair, that of D. B., has considerable limitation of motion. Flexion is not possible beyond 90 degrees and there is no internal or external rotation. She has no symptoms other than a limp which resembles a guarded gait. This

patient had symptoms for a period of one year and four months before seeking treatment. There is no history of trauma. However, she did receive some manipulative treatments at the hands of a chiropractor before obtaining medical advice. X-rays reveal normal joint width and no evidence of degenerative changes; however, there is some residual deformity amounting to a backward tilt of the head on the neck.

It is interesting to note that there are six cases in this series in which there was bilateral slipping. In three cases the second hip slipped after the wedge osteotomy and was picked up fairly early. These three hips were treated by simple internal fixation. In three of them the range of motion in the hip with the osteotomy is better than or equal to the hip nailed. Two cases were not noted until x-ray was taken as follow-up study. In the other there is very little difference between the two hips. The sixth hip, as previously mentioned, has not yet received treatment for it is planned to do a subtrochanteric osteotomy at a later date because of the presence of arthritic changes.

There is apparently no correlation between the duration of symptoms before surgery and the result obtained. The average duration of symptoms in the various results seen is as follows: excellent eleven months, good six months, fair eighteen months and poor ten months.

After excluding the one case in the excellent results which had gone on for two and a half years before surgery, the average duration of symptoms would still be nine months, not an appreciable difference from the poor results.

It is interesting to note that of all the cases there was an increase in the range of motion noted in sixteen of the hips post-operatively, whereas there was a decreased range of motion noted in only four patients after surgery. These four cases include the three cases rated as poor and the fair result.

#### CASE HISTORIES

CASE 1. N. F., a male, aged thirteen years and six months, was admitted to the hospital

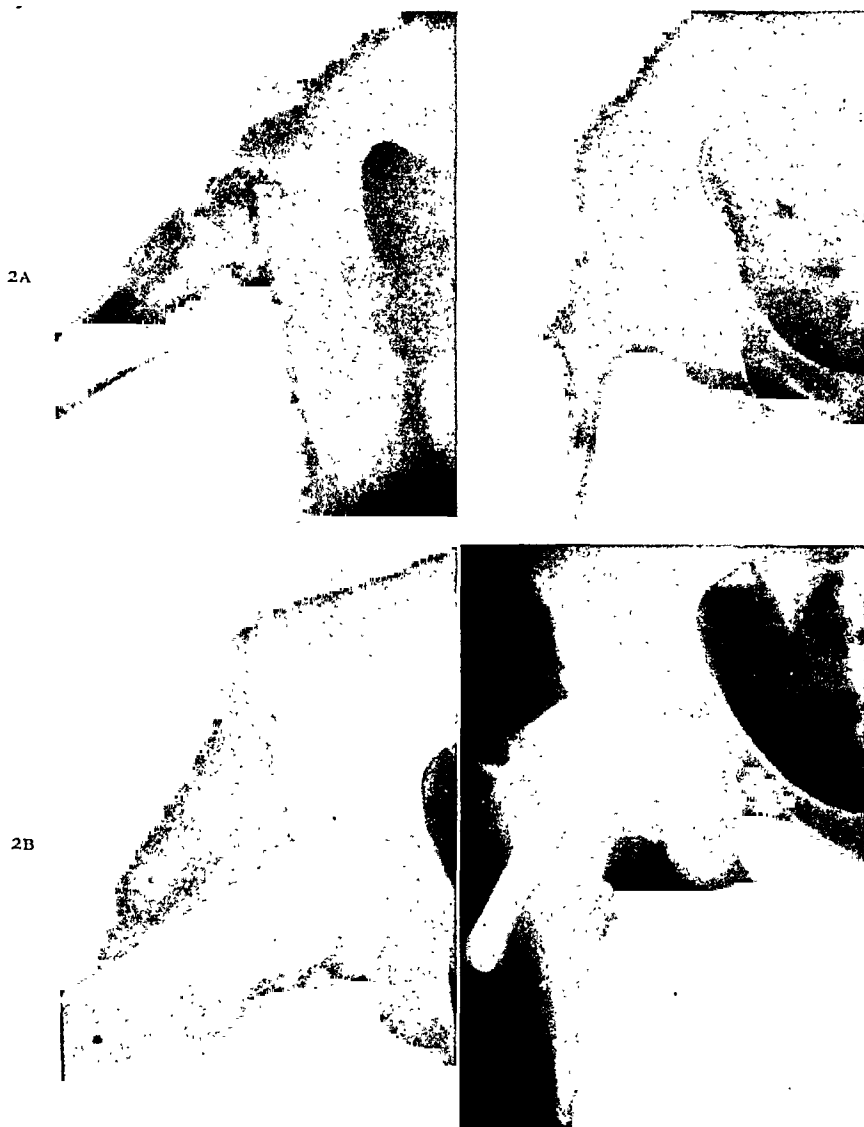


FIG. 2. A, case N. F., preoperative x-rays, November 4, 1938; B, follow-up x-rays, June 22, 1946.

November 5, 1938, complaining of pain in the right hip and a limp. There was a history of trauma to the right hip five months prior to admission. Physical examination revealed a slender, normally developed youth who did not demonstrate any manifestations of Fröhlich's syndrome. There was marked limitation of motion in the right lower extremity and in the right lower extremity, flexion being possible only to 125 degrees. Internal rotation was possible from 45 to 20 degrees less than the neutral position. There was  $\frac{1}{2}$  inch shortening of the right lower extremity. X-ray examination (Fig. 2A) revealed a marked downward and backward displacement of the

right femoral head upon the neck confirming the clinical diagnosis of slipped femoral epiphysis.

On November 9, 1938, a wedge osteotomy was performed through the neck of the right femur just distal to the epiphyseal plate. Reduction of the fragments was obtained and these were held by means of a Smith-Petersen nail. The patient was kept in bed for two weeks and then was allowed up to walk with crutches, not bearing weight on the involved extremity. He used crutches for six months following operation until he resumed full activities.

This case was complicated by the occurrence

of a slipped epiphysis on the left side which was noticed ten months following the operation on the right. The patient had symptoms of pain and limp for three weeks prior to his second admission. X-ray at this time showed a marked posterior slipping of the left femoral head. On September 23, 1939, the left hip was treated by fixation with a simple Smith-Petersen nailing after arthrotomy had revealed that the displacement was not as great as had been expected. The patient was confined to bed for three weeks and then was allowed up on crutches with a 1 inch raise on the left shoe. He used crutches and did not bear weight on the left lower extremity for four months before resuming normal activities.

The patient was last seen on June 22, 1946, eight and a half years following the wedge osteotomy on the right. The patient had no complaints referable to either hip. He works as a pressman which necessitates his being on his feet most of the working day. Examination at the time of this follow-up was as follows:

	Right	Left
Leg lengths.....	36 $\frac{3}{4}$ inches	37 inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	120 degrees	135 degrees
Internal rotation.....	25 degrees	10 degrees
External rotation.....	45 degrees	30 degrees
Abduction.....	30 degrees	25 degrees
Adduction.....	20 degrees	15 degrees

X-ray examination (Fig. 2B) at that time showed both femoral heads to be somewhat enlarged but the acetabulae conformed to them. The joint width was normal. Both nails were *in situ* and buried in bone.

CASE II. M. K., a male, aged thirteen years, was admitted to the hospital December 24, 1938, with the complaint of a limp for six months and pain for three months. He gave a definite history of trauma three months prior to admission. Physical examination revealed a rather obese boy with limitation of motion in the right hip. Flexion was equal on both sides. However, internal rotation was limited to 5 degrees and external rotation to 15 degrees on the right. There was only a 10 degree abduction. X-ray examination of the hips (Fig. 3A) revealed a backward and downward displacement of about 25 per cent of the right femoral epiphyseal head confirming the diagnosis of a slipped femoral epiphysis.

On December 28, 1938, a wedge osteotomy was performed through the right femoral neck.

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The fragments were reduced and fixed by means of a Smith-Petersen nail. The patient was confined to bed for three and a half weeks and then was allowed up on crutches, not bearing weight on the right lower extremity. The patient did not bear weight for five months, continuing to use crutches until he resumed his full activities.

The nail was removed June 28, 1940 from the right hip. The patient was last seen July 27, 1946, eight and a half years post-operative. The patient complained of no symptoms referable to the hip other than occasional snapping when he assumed some awkward position. There was no pain or symptoms with weather changes and his activities were unrestricted. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	35 $\frac{1}{4}$ inches	36 $\frac{1}{4}$ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	130 degrees	140 degrees
Internal rotation.....	15 degrees	15 degrees
External rotation.....	30 degrees	60 degrees
Abduction.....	25 degrees	30 degrees
Adduction.....	25 degrees	25 degrees

X-ray taken at this time (Fig. 3B) revealed a very small area of aseptic necrosis which presented smooth and clean-cut boundaries. The articular surfaces were very smooth and the joint width was normal.

CASE III. D. C., a male, aged thirteen years, four months, was admitted to the hospital July 15, 1939, with the complaint of pain and limp for seven months prior to admission. The patient gave a definite history of trauma stating he fell off a hayrack one year prior to admission to the hospital. Examination revealed a very obese boy with the general appearance of a Fröhlich type. There was some limitation of motion of the right hip. Flexion was quite normal. However, there was no internal rotation and external rotation was limited to 10 degrees. There was only 10 degrees of abduction. The right lower extremity was  $\frac{1}{2}$  inch shorter than the left. X-ray examination of the hips at this time (Fig. 4A) formed the clinical diagnosis of a slipped femoral epiphysis in that it showed considerable old downward displacement of the right femoral head upon the neck.

On July 18, 1939, a wedge osteotomy was done through the neck of the right femur. The fragments were reduced and fixed by



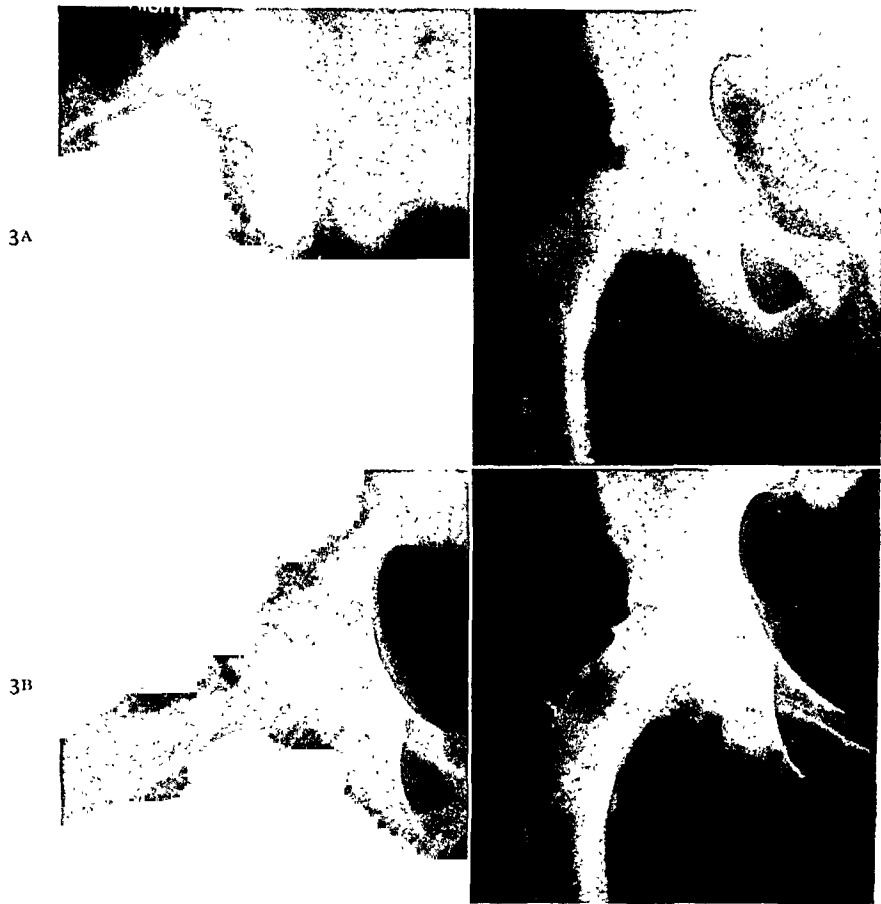


FIG. 3. A, case M. K., preoperative x-rays, December 24, 1938; B, follow-up x-rays, July 27, 1946.

means of a Smith-Petersen nail. The patient was in a plaster spica two weeks postoperatively and then confined to bed for another week before getting up on crutches. The patient was on crutches with no weight bearing on the right lower extremity for three months before resuming full activities.

On September 5, 1941, the nail was removed. The patient was last seen on September 23, 1946, five years postoperatively. At this time he appeared to be a well developed young man with no evidence of obesity. The patient had no symptoms referable to his hip. He works as a photoengraver which necessitates standing most of the day. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	36¾ inches	37 inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	120 degrees	130 degrees
Internal rotation.....	7 degrees	20 degrees
External rotation.....	45 degrees	40 degrees
Abduction.....	30 degrees	40 degrees
Adduction.....	25 degrees	25 degrees

X-ray examination at that time (Fig. 4B) revealed a very minimal residual deformity in the right hip. The joint looked normal except for a very slight sclerosis of the roof of the acetabulum.

CASE IV. V. P., a female, aged eleven years, entered the hospital July 1, 1940, with a complaint of pain and limp in the right lower extremity. The patient gave a history of trauma six weeks prior to admission at which time she stated she fell upon the involved extremity. Examination at this time revealed a moderately obese young girl with some limitation of motion in the right hip. There was no internal rotation and external rotation was markedly limited as was also abduction. X-ray examination (Fig. 5A) at this time revealed a downward and backward displacement of the right femoral head consistent with the diagnosis of a slipped femoral epiphysis.

On July 3, 1940, a wedge osteotomy was performed on the right hip and the fragments reduced and held with a Smith-Petersen nail.



FIG. 4. A, case D. C., preoperative x-rays, July 15, 1939; B, follow-up x-rays, September 23, 1946.

The patient was kept in a plaster spica for ten days. After three weeks she was allowed out of bed and walked with the help of crutches, not bearing weight on the right lower extremity. After a period of non-weight-bearing for three and a half months she was allowed to discard her crutches and resume normal activity.

The nail was removed on June 24, 1942. The patient was last seen October 7, 1946, at which time it was noted that she was quite a well developed young woman. She had no symptoms whatever referable to the right hip. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	35½ inches	35½ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	120 degrees	110 degrees
Internal rotation.....	45 degrees	45 degrees
External rotation.....	45 degrees	45 degrees
Abduction.....	30 degrees	30 degrees
Adduction.....	25 degrees	25 degrees

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X-ray examination at that time (Fig. 5B) revealed slight overgrowth of the greater trochanter. The hip joint appeared normal in width. The head showed no evidence of circulatory disturbance.

CASE V. C. R., a female, aged thirteen years, was admitted to the hospital September 23, 1940, with the complaint of pain and limp of the right lower extremity of eight months' duration. No history of trauma was elicited. Physical examination revealed a well developed girl who was not obese. There was a marked limitation of motion of the right hip, the range of flexion being only 5 degrees. There was an internal rotation deformity of 30 degrees. Abduction was limited to zero. There was ¾ inch shortening of the right lower extremity. X-ray examination at this time (Fig. 6A) of the hips revealed a marked downward and posterior displacement of the head on the neck,

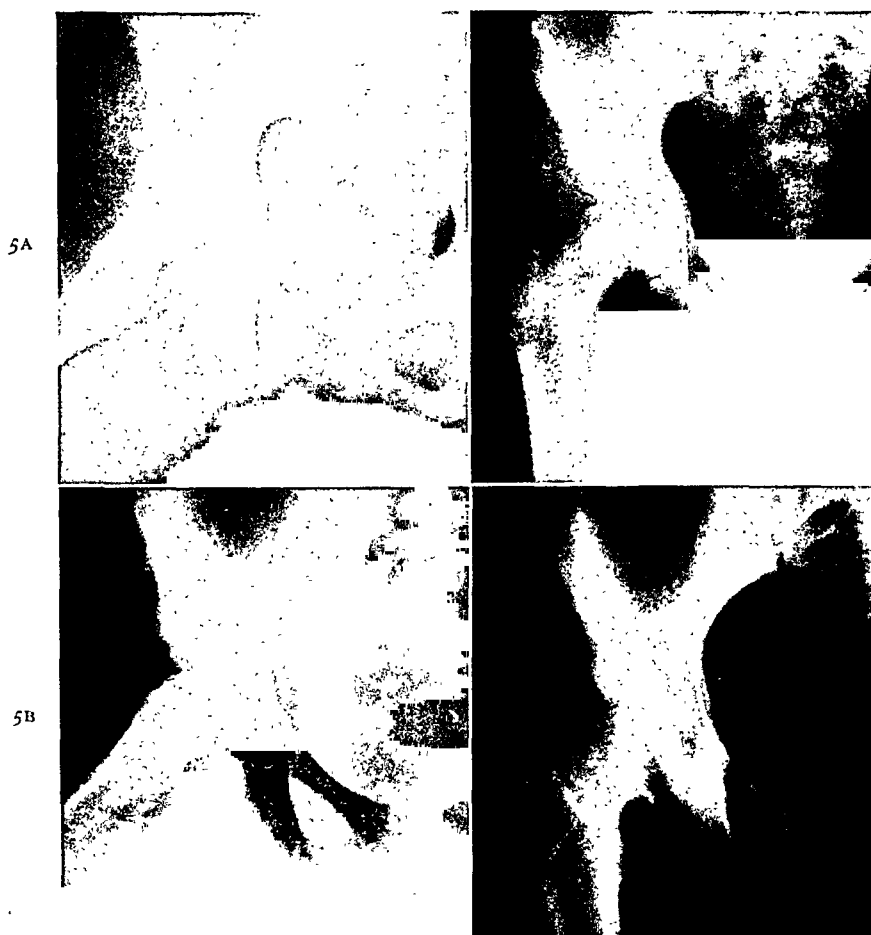


FIG. 5. A, case V. P., preoperative x-rays, July 1, 1940; B, follow-up x-rays, October 7, 1946.

the displacement being about 50 per cent. The shape of the femoral neck was markedly distorted due to this displacement.

On September 27, 1940, a wedge osteotomy of the right femoral neck was performed. The fragments were reduced and held in place by a Smith-Petersen nail. A plaster spica was applied which was removed after a period of three weeks and the patient was allowed out of bed with a raise on the opposite shoe and crutches at the end of four weeks. The patient was ambulatory and non-weight-bearing on the right lower extremity for five months post-operatively before she discarded her crutches and resumed full activity. The nail was removed November 28, 1941.

This patient was last seen as a follow-up on June 22nd, 1946. At that time she was a well developed girl with no deformity and absolutely symptom-free as far as the hip was concerned. X-rays of the hips (Fig. 6B) showed

only a slight residual deformity of backward and downward tilting of the head. The joint width was normal. Examination of the hips was as follows:

	Right	Left
Leg lengths.....	36½ inches	36¾ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	140 degrees	100 degrees
Internal rotation.....	30 degrees	35 degrees
External rotation.....	35 degrees	60 degrees
Abduction.....	30 degrees	40 degrees
Adduction.....	20 degrees	35 degrees

CASE VI. S. G., a male, aged thirteen years, was admitted to the hospital February 26, 1942, with the complaint of pain and limp of the right hip eight months prior to admission. Although there was no history of trauma with the original onset of pain, there was a definite history of trauma just prior to admission which caused a severe exacerbation of pain necessi-



FIG. 6. A, case C. R., preoperative x-rays, September 23, 1940; B, follow-up x-rays, June 22, 1946.

tating bed rest. Examination revealed a well developed boy who was not at all obese. There was considerable limitation of motion of the right hip with a range of flexion of only 25 degrees. There was a definite deformity of internal rotation and abduction was limited. X-ray examination of the hips at this time (Fig. 7A) revealed a very severe degree of downward and backward displacement of the right femoral head. This displacement was about 40 per cent.

On March 7, 1942, a wedge osteotomy with reduction of the fragments and a Smith-Petersen nailing was performed. A plaster spica was applied which was removed at the end of two and a half weeks postoperatively.

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Walking was instituted four weeks postoperatively, with non-weight-bearing on the right lower extremity by means of a raise on the shoe on the opposite side and crutches. The patient used crutches for seven months postoperatively when he resumed full activity. On February 3, 1943, the nail was removed. One point of the nail protruded into the joint until removed.

This patient was last seen as a follow-up on July 6, 1946. At that time the only symptom referable to his hip was what he called an occasional stiffness about the hip after extreme exercise. It is interesting to note that the day prior to coming to the hospital for this examination he had ridden a bicycle twenty miles.



FIG. 7. A, case S. G., preoperative x-rays, February 26, 1942; B, follow-up x-rays, July 6, 1946.

Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	41 inches	42½ inches
A.G.E.....	170 degrees	180 degrees
Range of flexion.....	70 degrees	130 degrees
Internal rotation.....	0 degrees	20 degrees
External rotation.....	0 degrees	30 degrees
Abduction.....	20 degrees	30 degrees
Adduction.....	15 degrees	30 degrees

X-ray examination of the hips at that time (Fig. 7B) revealed some residual deformity in the right femoral neck. There was fairly good preservation of joint space; no aseptic necrosis was seen.

At the time of the follow-up examination this boy was 6 feet 5 inches tall. This more than usual growth in stature over the past four years may account for the 2½ inch shortening

of the right lower extremity in that the femoral capital epiphysis was fused at the age of thirteen.

CASE VII. E. C., a male, aged fifteen years, was admitted to the hospital July 13, 1942, with a complaint of pain and limp of the left lower extremity and left hip for five months prior to admission. No history of trauma was elicited. Examination revealed a well developed boy who was slightly overweight but not obese. He walked with a decided limp on the left and there was considerable muscle spasm on the left with limitation of motion of the hip. Flexion was limited to 90 degrees. There was no internal rotation and external rotation and abduction were markedly limited. X-ray examination of the hips (Fig. 8A) revealed a downward and posterior displacement of the left femoral head. The femoral epiphyseal



FIG. 8. A, case E. C., preoperative x-rays, July 13, 1942; B, follow-up x-rays, June 29, 1946.

cartilage on the left was much thinner and there was a suggestion of fusion between the head and the neck posteriorly and inferiorly.

On July 20, 1944, a wedge osteotomy through the left femoral head was performed. The fragments were fixed with a Smith-Petersen nail. A plaster spica was applied for three weeks when the patient was allowed out of bed and walked with a raise on the opposite shoe, using crutches for five weeks postoperatively. He was ambulatory, non-weight-

bearing on the left lower extremity for six months before he discarded his crutches and resumed full activity. The nail was removed August 20, 1943.

This patient was last seen as a follow-up on June 29, 1946. At that time he was without symptoms about the left hip. He stated there was only an occasional sense of tightness which he experienced when the hip would occasionally be put in an awkward position. He works in a library and is on his feet most of the day.

*September, 1949*

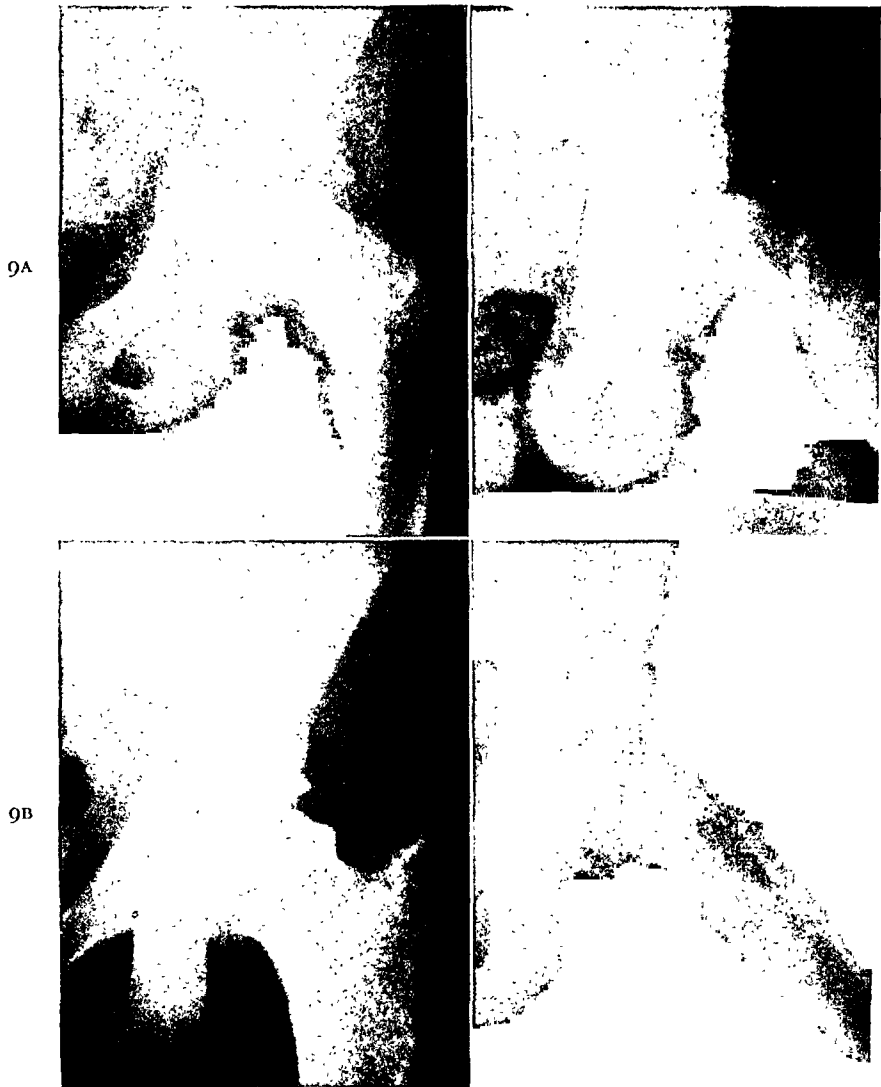


FIG. 9. A, case A. M., preoperative x-rays, February 15, 1943; B, follow-up x-rays, October 16, 1946.

Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	39 inches	38¾ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	135 degrees	130 degrees
Internal rotation.....	30 degrees	5 degrees
External rotation.....	50 degrees	35 degrees
Abduction.....	45 degrees	40 degrees
Adduction.....	30 degrees	30 degrees

X-ray examination (Fig. 8B) revealed only a very slight residual deformity in the left hip. There was good preservation of the joint cartilage. There was no evidence at this time of any joint disorder.

CASE VIII. A. M., a male, aged fourteen years, five months, was admitted to the hospital February 15, 1943, with the complaint of

pain and limp seven months prior to admission. A definite history of trauma was elicited, having occurred one year and seven months prior to admission, which was a year before the onset of the symptoms. At that time he had some pain and there was some limp in the affected hip. However, this subsided in two months and did not recur for another year. Physical examination at this time revealed an obese boy manifesting signs of Fröhlich's syndrome. There was limitation of motion of the left lower extremity and a shortening of 1 inch. Flexion was possible only to 80 degrees. Internal rotation was not possible beyond 25 degrees less than the neutral position. X-ray examination of the hips at this time (Fig. 9A) revealed downward displacement of

the femoral head and a slight flattening of the anatomic neck.

On February 17, 1943, a wedge osteotomy was done through the left femoral neck. The fragments were reduced and held in place by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for three weeks postoperatively. The patient was ambulatory four weeks postoperatively with a raise on the opposite shoe and with the aid of crutches. These were used for six months postoperatively before they were discarded and the patient allowed to resume full activity. The nail was removed August 6, 1943.

This patient was last seen as a follow-up on October 16, 1946. At that time he seemed to be a well developed young man with normal secondary sex characteristics. There were no residual symptoms referable to the left hip. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	39 $\frac{3}{4}$ inches	39 $\frac{1}{4}$ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	130 degrees	120 degrees
Internal rotation.....	0 degrees	5 degrees
External rotation.....	60 degrees	45 degrees
Abduction.....	35 degrees	30 degrees
Adduction.....	25 degrees	25 degrees

The more marked limitation of internal rotation on the right can be explained by an unnoticed and asymptomatic slipping of the right femoral epiphysis which was demonstrated upon x-ray examination. X-ray examination at that time of the hips (Fig. 9B) revealed excellent alignment of the left hip at the head and neck. There was no evidence of circulatory disturbance and the joint cartilages were well preserved. However, it was noted that since his last examination in February, 1943, there was a considerable degree of slipping of the right femoral epiphyseal head. This, however, was now solidly united to the neck and there was some downward and backward displacement, the deformity of the right hip being in excess of that on the left.

CASE IX. M. A'H., a female, aged thirteen years, was admitted to the hospital March 29, 1943, with the complaint of pain and limp of the right hip and lower extremity a year and a half prior to admission. A definite history was elicited one and a half years before admission at which time the patient fell down a flight of steps. Examination revealed a rather large girl with a definite tendency toward

obesity. She walked with a definite limp and there was some restriction of motion of the right lower extremity. There was  $\frac{1}{2}$  inch shortening on the right. Internal rotation was not possible beyond 35 degrees less than the neutral position. Abduction was markedly diminished. X-ray examination of the hips at this time (Fig. 10A) revealed a marked downward and backward slipping of the right femoral epiphyseal head. There was also deformity of the femoral neck. The femoral epiphysis was almost closed.

On March 31, 1943, a wedge osteotomy through the right femoral neck was performed, the fragments reduced and held in place by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for 2 $\frac{1}{2}$  weeks postoperatively. Four weeks postoperatively the patient was ambulatory, using crutches and wearing a raise on the opposite shoe. The patient used crutches and a raise on the shoe for nine months, not bearing weight on the right lower extremity. After this time she resumed full activity. The nail was removed November 8, 1944.

This patient was last seen as a follow-up July 27, 1946. At that time it was noted that she was markedly obese for her age, weighing 185 pounds. She did not walk with a limp but her mother stated that when the girl was tired a slight limp on the right side was noticed. The only symptom referable to the hip was an occasional twinge of pain in the right hip or knee at night, especially after strenuous activity. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	34 $\frac{3}{4}$ inches	35 $\frac{3}{4}$ inches
A.G.E.....	175 degrees	180 degrees
Range of flexion.....	85 degrees	120 degrees
Internal rotation.....	5 degrees	20 degrees
External rotation.....	10 degrees	30 degrees
Abduction.....	15 degrees	25 degrees
Adduction.....	20 degrees	30 degrees

X-ray examination of the hips (Fig. 10B) revealed a slight varus deformity of the right hip with a slight residual backward tilt of the head. The articular surfaces of the head and acetabulum conformed well. There was good preservation of the joint cartilage and no evidence of circulatory disturbance.

CASE X. R. V., a male, aged thirteen years, four months, was admitted to the hospital August 3, 1943, with the complaint of pain in the left hip and knee with a limp and restricted



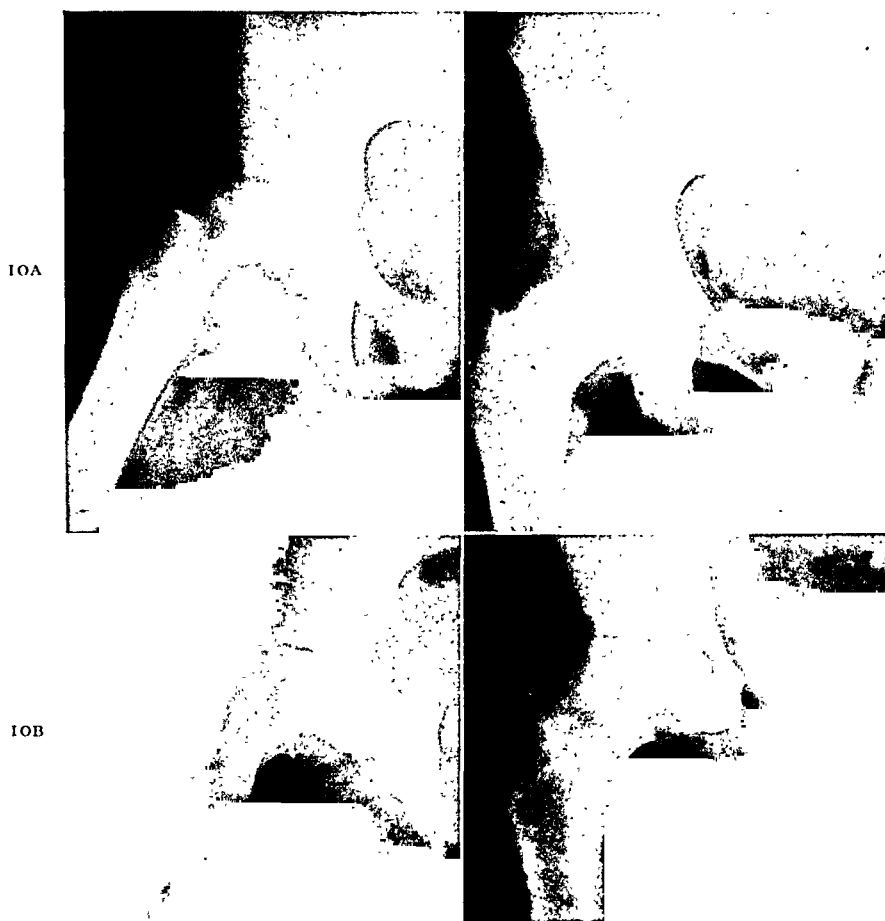


FIG. 10. A, case M. A'H., preoperative x-rays, March 29, 1943; B, follow-up x-rays July 27, 1946.

motion of the left hip of five months' duration. A definite history of trauma was elicited five months before the admission at which time the patient fell on his left hip. Examination at this time revealed a rather obese boy with some manifestations of Fröhlich's syndrome. There was some limitation of flexion. Internal rotation was markedly limited, not being possible beyond 45 degrees less than the neutral position. X-ray examination of the hips at this time (Fig. 11A) revealed a downward and backward displacement of the left femoral epiphyseal head which amounted to about 30 per cent.

On August 5, 1943, a Leadbetter manipulation was attempted on the left hip but was unsuccessful. On August 11, 1943, a wedge osteotomy through the left femoral neck was performed, the fragments reduced and held in place by means of a Smith-Petersen nail. A plaster spica was applied and this was maintained for ten days postoperatively. The

patient was ambulatory four weeks postoperatively, using crutches and wearing a raise on the opposite shoe. He continued to be ambulatory in this fashion for eight months postoperatively before discarding crutches and resuming activity.

This case was complicated by the development of a minimal slipping of the femoral epiphysis on the right side which was noticed March 1, 1944, seven months after his first admission. At that time the patient complained of some pain in the right hip referred down to the knee. X-ray examination (Fig. 11B) revealed a minimal haziness about the epiphyseal line and minimal slipping of the femoral head. Clinical examination at this time did not reveal any limitation of motion. However, it was decided to nail the right hip to prevent further slipping. This was done on March 22, 1944. The patient was non-weight-bearing on the right lower extremity three months postoperatively.



FIG. 11. A, case R. V., preoperative x-rays left hip, August 3, 1943.



FIG. 11. B, case R. V., preoperative x-rays right hip, March 1, 1944.



FIG. 11. C, case R. V., follow-up x-rays both hips, June 7, 1946.

This patient was last seen on June 7, 1946, as a follow-up. Examination of the hips at that time was as follows:

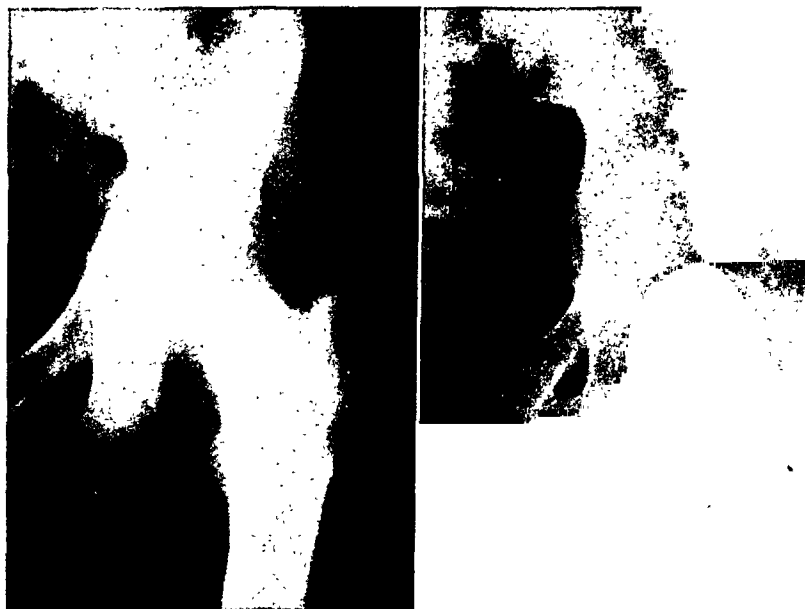
	Right	Left
Leg lengths.....	37 $\frac{3}{4}$ inches	37 $\frac{3}{4}$ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	110 degrees	110 degrees
Internal rotation.....	10 degrees	15 degrees
External rotation.....	45 degrees	35 degrees
Abduction.....	30 degrees	40 degrees
Adduction.....	30 degrees	25 degrees

At that time the patient was a well developed, normal, young man with no residual evidences of Fröhlich's syndrome. He had absolutely no symptoms whatsoever referable to either hip. X-ray examination of the hips at this time (Fig. 11c) revealed excellent alignment of both hips. The joint cartilages

of both hips were well preserved. There was no evidence of any circulatory disturbance.

CASE XI. A. C., a male, aged fifteen years, was admitted to the hospital August 16, 1943, with a complaint of limp and pain in the left hip which had persisted for seven months. There was a definite history of trauma. The patient stated he fell from a bicycle seven months prior to admission and his symptoms came on shortly after this. Physical examination revealed a well developed boy of fifteen years who walked with a left-sided limp. There was  $\frac{1}{2}$  inch shortening of the left lower extremity. Flexion was limited to 90 degrees. Internal rotation was not possible beyond 15 degrees less than the neutral position. X-ray examination of the hips at that time (Fig. 12A) revealed a marked downward and

12A



12B

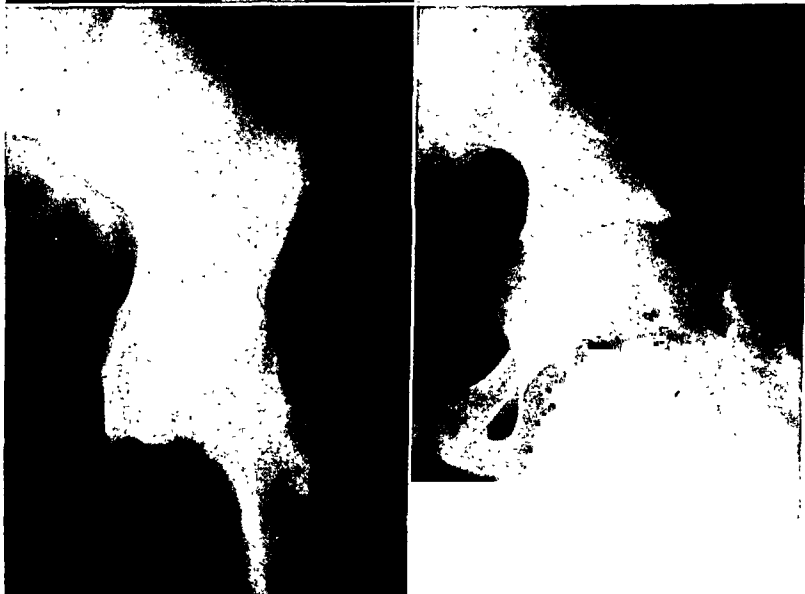


FIG. 12. A, case A. C., preoperative x-rays, August 16, 1943; B, follow-up x-rays July 6, 1946.

backward displacement of the left femoral epiphyseal head.

On August 20, 1943, a wedge osteotomy was performed through the left femoral neck just distal to the epiphyseal plate. The fragments were reduced and position maintained by means of a Smith-Petersen nail. A single hip spica was applied which was removed after a period of two weeks. The patient was allowed to be ambulatory four weeks postoperatively with the use of crutches and a 1 inch raise on the opposite shoe. Non-weight-bearing of the

involved extremity was maintained for eight months postoperatively after which time the patient resumed full activities. The nail was removed October 6, 1944.

This patient was last seen July 6, 1946, as a follow-up, three years following the wedge osteotomy. At that time the patient was a well developed young man of eighteen. He walked with a slight limp on the left. The patient complained of occasional pain in the left knee associated with weather changes but not constant. He also noted that after strenuous

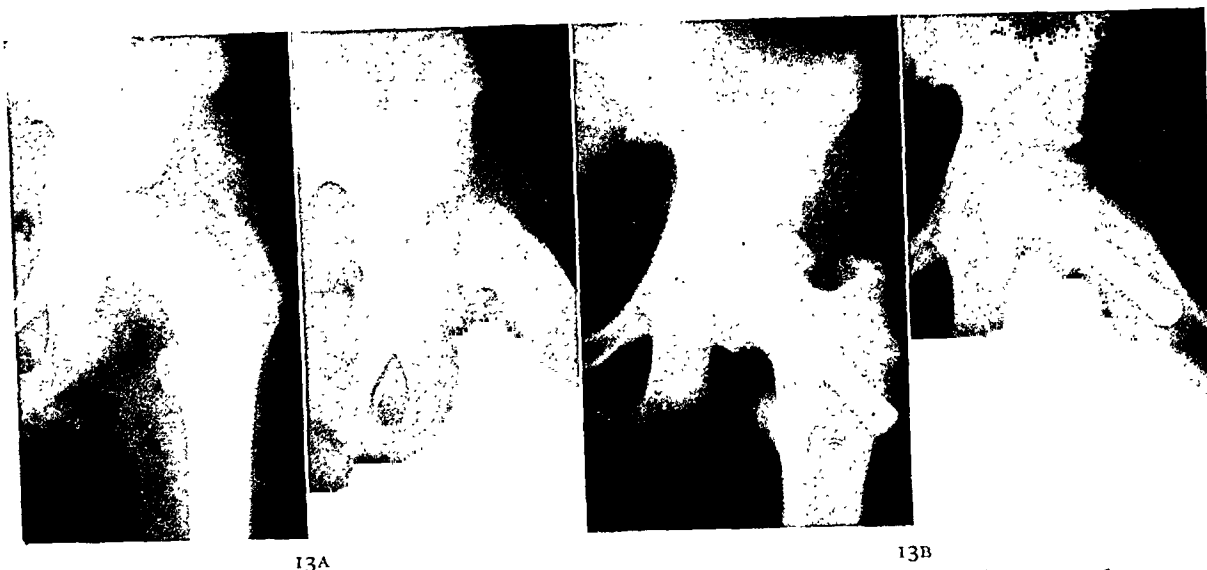


FIG. 13. A, case O. S., preoperative x-rays, November 24, 1943; B, follow-up x-rays, July 3, 1946.

exercise or full activity the knee might be stiff for a day or two. Examination of the hips at this time was as follows:

	Right	Left
Leg lengths.....	36 $\frac{1}{4}$ inches	35 $\frac{1}{2}$ inches
A.G.E.....	180 degrees	150 degrees
Range of flexion.....	135 degrees	60 degrees
Internal rotation.....	30 degrees	0 degrees
External rotation.....	50 degrees	0 degrees
Abduction.....	35 degrees	5 degrees
Adduction.....	25 degrees	5 degrees

X-ray examination of the hips at that time (Fig. 12B) revealed that the cartilage of the left hip joint was distinctly narrower than the right. The femoral head was enlarged and there was a considerable amount of lipping about the head and neck. There were also areas of increased and decreased density in the femoral head and a good deal of sclerosis in the acetabulum. These changes probably are a result of irregular zones of aseptic necrosis.

CASE XII. O. S., a male, aged thirteen years, was admitted to the hospital November 24, 1943, with a complaint of intermittent pain on the outside of the left knee of six months' duration. The patient gave a history of trauma due to a fall two months prior to admission. Following this he had pain in the left hip and thigh with a limp. Physical examination at this time revealed a moderately obese boy with some evidences of endocrine disturbance. He walked with a slight limp. Examination of the hips revealed limitation of flexion, internal rotation and abduction. Internal rotation was not possible beyond 20 degrees less than the

neutral position. X-ray examination of the hips at this time (Fig. 13A) revealed a marked downward and backward displacement of the left femoral head. There was also considerable deformity of the adjacent portion of the neck.

On December 1, 1943, a wedge osteotomy through the left femoral neck was performed, the fragments reduced and held by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for two weeks postoperatively. The patient was ambulatory three weeks postoperatively, using crutches and a raise on the opposite shoe. Non-weight-bearing of the involved extremity was accomplished by this means for eleven months before the patient was allowed full activity.

This patient was last seen on July 3, 1946, as a follow-up two and a half years postoperatively. Examination at this time revealed a boy sixteen years of age, well developed, with no evidence of Fröhlich's syndrome. The patient had no symptoms referable to the left hip. He was enjoying full activities. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	35 $\frac{3}{4}$ inches	35 $\frac{3}{4}$ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	120 degrees	115 degrees
Internal rotation.....	30 degrees	30 degrees
External rotation.....	60 degrees	45 degrees
Abduction.....	40 degrees	40 degrees
Adduction.....	35 degrees	30 degrees

X-ray examination of the hips at that time (Fig. 13B) revealed excellent alignment with



FIG. 14. A, case D. B., preoperative x-rays, January 24, 1944; B, follow-up x-rays, September 14, 1946.

complete healing of the epiphysis. There was no narrowing of the joint cartilage. The nail was still in place and there was no evidence of softening along the nail.

CASE XIII. D. B., a female, aged fourteen years, seven months, was admitted to the hospital on January 24, 1944, with the complaint of a limp on the right one year and four months prior to admittance. She at no time had an injury and there was no pain referable either to hip or the knee. The limp became progressively worse in spite of chiropractic treatment. Physical examination revealed a well developed girl with no evidence of obesity who walked with a right-sided limp. There was limitation of motion of the right hip, the right lower extremity being held in about 25 degrees of external rotation. It was not possible to rotate internally the extremity beyond this point. There was also a 20 degree flexion contracture of the right hip and flexion was possible only to 90 degrees. X-ray examination at that time (Fig. 14A) of the hips revealed a marked downward and backward displacement of the right femoral epiphysal head.

On January 26, 1946, a wedge osteotomy was performed on the right femoral head just distal to the epiphysal plate. The fragments were reduced and held in position by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for two weeks postoperatively. The patient was made ambulatory three weeks postoperatively using crutches and a raise on the opposite shoe. This was continued for seven months before she was allowed full weight-bearing on the involved extremity.

The patient was last seen as a follow-up on

September 14, 1946, two years and nine months following the wege osteotomy. Examination at that time revealed a well developed and rather large but not obese girl seventeen and a half years of age. She walked with a slight right-sided limp. However, she had no symptoms or pain referable to either the hip or the knee and she enjoys full activities. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	37½ inches	38 inches
A.G.E.....	175 degrees	180 degrees
Range of flexion.....	85 degrees	105 degrees
Internal rotation.....	0 degrees	25 degrees
External rotation.....	0 degrees	40 degrees
Abduction.....	10 degrees	30 degrees
Adduction.....	10 degrees	20 degrees

X-ray examination of the hips (Fig. 14B) revealed only a very slight residual deformity with slipping of the head upon the neck. The nail was still in place with no evidence of softening about it. The joint cartilages were not diminished in width.

CASE XIV. P. DiM., a female, aged twelve, was admitted to the hospital May 1, 1944, with the complaint of pain and limp of the right hip of six months' duration prior to admission. Physical examination revealed a well developed girl who demonstrated the typical disability of the upper right extremity of an Erb's Palsy. She walked with a noticeable limp. Examination of the hips revealed limitation of flexion and internal rotation on the right. The extremity was held in 15 degree external rotation and internal rotation was not possible beyond this point. X-ray examination of the hips (Fig. 15A) revealed a moderate downward and backward slipping of the femoral epiphysal head on the right.

On May 3, 1944, a wedge osteotomy was performed through the right femoral neck just distal to the epiphyseal plate. The fragments were reduced and held in position by means of a Smith-Petersen nail. A flannel spica bandage was applied to the right hip. The patient was confined to bed for three weeks before she was allowed to be ambulatory at which time she used crutches and a 1 inch raise on the opposite shoe. She continued to be ambulatory without bearing weight on the right lower extremity for five months after which time she resumed full activities.

This patient was last seen July 10, 1946, as



FIG. 15. A, case P. DiM., preoperative x-rays, May 1, 1944.



FIG. 15. B, case P. DiM., follow-up x-rays both hips, July 10, 1946.

a follow-up two years following the wedge osteotomy on the right. Examination at this time revealed a moderately obese girl of fourteen years. She did not walk with a limp and had no symptoms referable to the right hip or knee. Examination of the hips was as follows:

	Right	Left
Leg lengths.....	32¼ inches	32½ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	120 degrees	135 degrees
Internal rotation.....	20 degrees	25 degrees
External rotation.....	70 degrees	80 degrees
Abduction.....	25 degrees	45 degrees
Adduction.....	33 degrees	30 degrees

X-ray examination of the hips at that time (Fig. 15B) revealed very good alignment of the head on the neck. The epiphysis was closed. There were some bony bodies seen anterior to the upper end of the right femur at the greater trochanter. There was good preservation of the joint space. The Smith-Petersen nail was present. There was no evidence of bony softening about it.

CASE XV. A. D'A., a male, aged twelve years, was admitted to the hospital April 21, 1945, with a complaint of pain and limp on the left seven months prior to admission. The only history of trauma elicited was that of September, 1949

twisting his ankle five days prior to admission. At that time the patient experienced some pain in the left knee and calf. Physical examination revealed a moderately obese young boy who showed some evidences of Fröhlich's syndrome. It is of some interest to state that a year prior to admission this patient was treated for undescended testicles and obesity by endocrine therapy. Examination of the hips revealed a limitation of motion on the left. The left extremity was held in 45 degree external rotation and internal rotation was not possible beyond this point. X-ray examination at this time revealed a marked downward and backward displacement of the left femoral epiphyseal head.

On April 25, 1945, a wedge osteotomy was performed through the left femoral neck. The fragments were reduced and held in place by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for ten days. On May 26, 1945, four weeks after having the wedge osteotomy on the left, the right femoral head was nailed with a Smith-Petersen nail because of the minimal slipping on this side. The patient was confined to bed and not allowed to bear weight on either hip for three months postoperatively. However,



FIG. 16. A, case A. D'A., follow-up x-rays both hips, January 29, 1947.

he did carry out rather intensive non-weight-bearing exercises while in bed. The patient became ambulatory three months after his last operation and continued to use crutches, not bearing weight on the left lower extremity for five months before resuming full weight-bearing but still limiting his activities.

The patient was last seen on January 29, 1947, one year and nine months following the wedge osteotomy on the left. At this time the patient was still on somewhat restricted activities in that he was discouraged from indulging in strenuous sports. The only complaint he had referable to either lower extremity was fatigue in both feet. The child is still somewhat obese and has moderately pronated feet. Examination of the hips at that time was as follows:

	Right	Left
Leg lengths.....	33½ inches	33¼ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	140 degrees	120 degrees
Internal rotation.....	15 degrees	10 degrees
External rotation.....	85 degrees	45 degrees
Abduction.....	30 degrees	35 degrees
Adduction.....	30 degrees	30 degrees

X-ray examination of the hips (Fig. 16A) revealed the epiphyseal lines in both hips to be solidly closed. There was good restoration of alignment in the left hip. Both nails were in place. There was evidence of slight absorption around the point of the nail in the right head. There was good preservation of the joint cartilages and no evidence of circulatory disturbances in either hip.

CASE XVI. P. B., a male, aged fifteen years, was admitted to the hospital August 2, 1944, with the complaint of pain and limp in the right hip of two and a half years' duration. The patient gave a definite history of trauma two and a half years prior to admission which resulted from a football injury. Shortly after

this the patient noted the symptoms referable to the right hip. The patient was treated at another hospital by means of a plaster spica for a period of four months. Following this the patient continued to limp and a few months later he complained of pain in the left hip. He was again treated at another hospital with a long leg plaster spica on the right and a short leg plaster spica on the left. This was maintained for a period of six months. Following this treatment the patient was asymptomatic for a period of two or three months before he noticed a recurrence of the limp and pain in the region of the right hip. Physical examination at the time of admission revealed a rather obese boy fifteen years of age whose general build and development was that of Fröhlich's syndrome with a feminine distribution of fat and hair. He walked with a marked limp on the right lower extremity. The extremity was held in 35 degree external rotation. There was marked limitation of motion of the right hip in all directions. Flexion was limited to 90 degrees. Internal rotation was not possible beyond the 35 degree external rotation deformity. Examination of the left hip at that time revealed normal range of motion. X-ray examination of the hips (Fig. 17A) showed a moderate downward and backward displacement of the left femoral epiphyseal head and there was quite a firm fusion of the epiphyseal line. There was also a backward and downward displacement of the right femoral head with no evidence of fusion of the epiphyseal plate.

On August 4, 1944, a wedge osteotomy was done through the femoral neck just distal to the epiphyseal plate. Correction was obtained and the fragments were held in place by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for two weeks. Three weeks postoperatively the patient became ambulatory using crutches and having

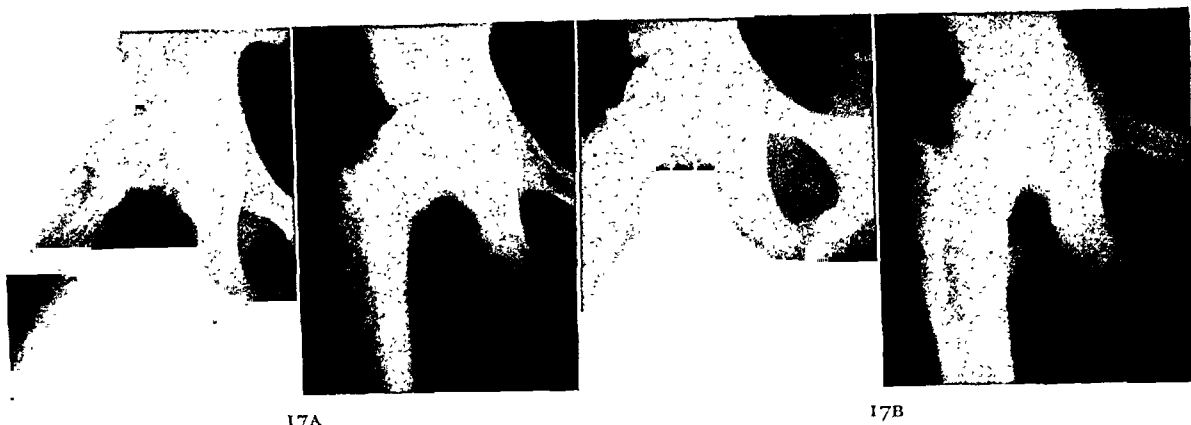


FIG. 17. A, case P. B., pre-operative x-rays, August 2, 1944; B, follow-up x-rays, April 15, 1946.

a lift on the left shoe. The patient was ambulatory, not bearing weight on the right lower extremity for ten and a half months postoperatively at which time the crutches were discarded. On March 22, 1946, the nail was removed.

The patient was last seen April 15, 1946, as a follow-up twenty-one months postoperatively. At this time the patient had no symptoms referable to the right hip. Examination revealed a well developed boy of seventeen years who had lost considerable weight and no longer demonstrated any signs of Fröhlich's syndrome. Examination of the hips revealed that the range of motion was essentially the same for both. Examination was as follows:

	Right	Left
Leg lengths.....	38 $\frac{1}{3}$ inches	38 $\frac{1}{3}$ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	100 degrees	105 degrees
Internal rotation.....	30 degrees	30 degrees
External rotation.....	40 degrees	40 degrees
Abduction.....	30 degrees	30 degrees
Adduction.....	35 degrees	35 degrees

X-ray examination of the hips at this time (Fig. 17B) revealed a very excellent alignment of the right femoral head and neck. There was solid union at the epiphyseal plate. There was good preservation of joint cartilages with no evidence of any circulatory disturbances.

CASE XVII. L. B., a male, aged eleven years, five months, was admitted to the hospital April 27, 1946, with a complaint of right sided limp and slight pain in the right knee. The patient gave a history of limp for one and a half years prior to admission. There was no history of trauma. Examination at the time of admission revealed a well developed, obese boy. Leg lengths were essentially the same.

September, 1949

Range of flexion and extension was the same in both hips. However, he had marked external rotation deformity of the right hip. He was not able to rotate it internally beyond a point of 45 degrees less than the neutral position. Abduction was limited by about 10 degrees. X-ray examination of the hips (Fig. 18A) revealed a marked degree of downward and posterior slipping of the right femoral epiphyseal head. The epiphyseal plate was still open.

On May 1, 1946, a wedge osteotomy through the neck of the right femur was performed just distal to the epiphyseal plate, the deformity corrected and the fragments fixed by means of a Smith-Petersen nail. Plaster spica was applied which was maintained for two weeks. At the end of three weeks the child was allowed to walk, non-weight-bearing on the right by means of crutches and an elevation on the opposite side shoe. He remained ambulatory, non-weight-bearing on the right lower extremity for a period of nine and a half months.

The patient was last seen in the clinic for end result study on July 25, 1947, fifteen months postoperatively. The child was absolutely symptom-free. He did not walk with a limp nor were his activities restricted insofar as competitive sports were concerned. Examination of the hips was as follows:

	Right	Left
Leg lengths.....	31 inches	31 $\frac{1}{2}$ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	120 degrees	135 degrees
Internal rotation.....	20 degrees	20 degrees
External rotation.....	80 degrees	80 degrees
Abduction.....	50 degrees	45 degrees
Adduction.....	30 degrees	30 degrees

X-ray examination at this time (Fig. 18B) revealed complete healing of the osteotomy





FIG. 18. A, case L. B., preoperative x-rays, April 27, 1946; B, follow-up x-ray, July 25, 1947.

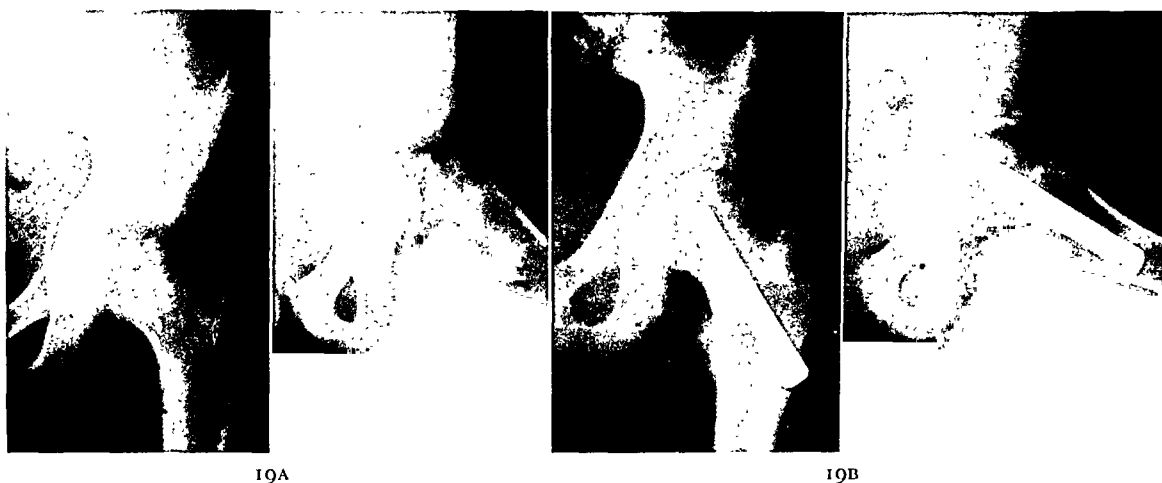


FIG. 19. A, case A. S., preoperative x-rays, May 4, 1946; B, follow-up x-rays, July 25, 1947.

with excellent alignment of the head on the neck. There was no evidence of necrosis of the head nor softening about the nail. There was good preservation of joint cartilage.

CASE XVIII. A. S., a male, aged thirteen years, seven months, was admitted to the hospital May 4, 1946, with a chief complaint of pain in the left thigh and a limp. There was no history of trauma. The symptoms prevailed for six months prior to admission. Examination at the time of admission revealed a moderately obese boy who had a  $1\frac{1}{4}$  inch shortening of the left lower extremity. Flexion was limited on the left to 90 degrees and extension to 150 degrees. He had a marked external rotation deformity, not being able to bring the extremity into more than 45 degrees less than the neutral position. Abduction was limited to about 20 degrees. X-ray examination at the time of admission revealed a marked degree of down-

ward and posterior displacement of the left femoral head. The epiphyseal plate was still open. (Fig. 19A.)

On May 8, 1946, a wedge osteotomy was performed through the left femoral neck just distal to the femoral epiphysis. The malalignment was corrected and the fragments fixed by means of a Smith-Petersen nail. A single long leg plaster spica was applied which was maintained for a period of two weeks. Four weeks postoperatively the patient was allowed to be ambulatory, non-weight-bearing on the left lower extremity provided by means of crutches and an elevated shoe on the right. Weight-bearing was not allowed on the left lower extremity for a period of nine and a half months.

The patient was last seen on July 25, 1947 at which time he had no symptoms referable to the hip. However, he did complain of some



FIG. 20. A, case R. B., preoperative x-rays, July 5, 1946; B, follow-up x-rays, August 1, 1947.

metatarsalgia. Examination of the hips at that time revealed:

	Right	Left
Leg lengths.....	36 inches	35½ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	110 degrees	115 degrees
Internal rotation.....	45 degrees	45 degrees
External rotation.....	80 degrees	70 degrees
Abduction.....	45 degrees	55 degrees
Adduction.....	25 degrees	30 degrees

X-ray examination (Fig. 19B) revealed healing to have taken place through the site of the osteotomy. There was a slight backward tilt of the head on the neck. There was good preservation of the joint cartilage and no evidence of necrosis of the head. There was some evidence of rarefaction about the distal end of the nail. At the time of operation there was a slight defect at the site of the osteotomy anteriorly; however, this apparently had completely filled in.

CASE XIX. R. B., a male, aged thirteen years, four months, was admitted to the hospital July 5, 1946, with a complaint of pain in the right hip of two weeks' duration. A history of trauma was elicited two days prior to admission at which time he slipped and felt sharp pain in the right hip which was so severe that the patient was unable to walk. Examination at the time of admission revealed a slightly obese boy. There was some limitation of flexion of the right hip and an external rotation deformity of 30 degrees. X-ray examination at this time (Fig. 20A) revealed a downward and posterior slipping of the right femoral head.

On July 10, 1946, a wedge osteotomy was performed through the femoral neck on the right just distal to the epiphysis. The malalignment was corrected and the fragments

fixed by means of a Smith-Petersen nail. A single long leg plaster spica was applied which was maintained for a period of two weeks. The child was allowed to be ambulatory five weeks postoperatively, with non-weight-bearing on the right by means of crutches and an elevated shoe on the left. He was not allowed to bear weight on this extremity for a period of eleven months.

The child was last seen in the clinic on August, 1947, at which time examination revealed a slightly obese boy who manifested no symptoms referable to the hip. He was on full activities with the exception of competitive sports. Examination of the hips at that time revealed:

	Right	Left
Leg lengths.....	36 inches	36¼ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	135 degrees	135 degrees
Internal rotation.....	20 degrees	20 degrees
External rotation.....	65 degrees	80 degrees
Abduction.....	45 degrees	45 degrees
Adduction.....	30 degrees	30 degrees

X-ray examination (Fig. 20B) revealed healing at the osteotomy site with good alignment of the head on the neck. There was good preservation of the joint cartilage and no evidence of circulatory disturbance of the neck.

CASE XX. J. S., a female, aged fourteen years, four months, was admitted to the hospital on April 21, 1947, with a complaint of pain in both hips and a limp of one and a half years' duration. She gave a history of trauma over a year and a half previously at which time she fell down the steps. There were no symptoms at this time but about three months later she developed pain in the right hip. Shortly thereafter she noted pain in the left hip which

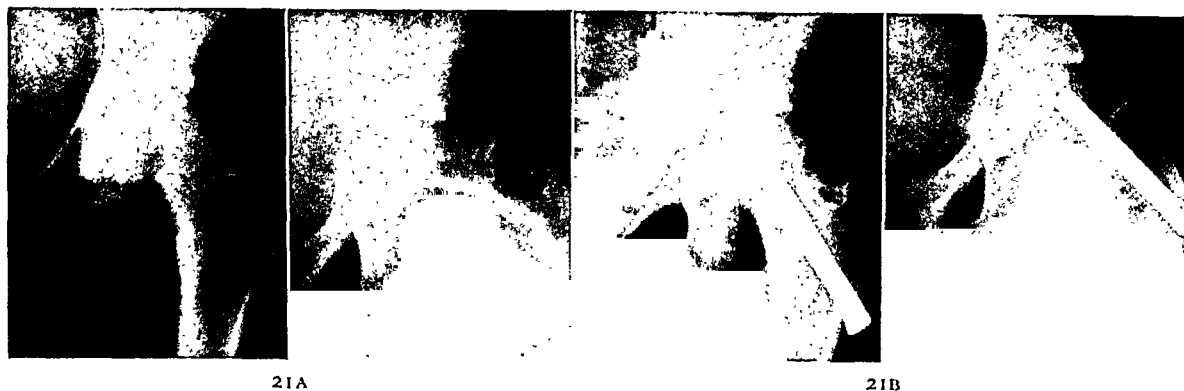


FIG. 21. A, case J. S., preoperative x-rays, April 21, 1947; B, follow-up x-rays, July 30, 1947.

was associated with a limp. Examination at the time of admission revealed the leg lengths to be about equal. There was no limitation of flexion or extension; there was an external rotation deformity of 15 degrees on both sides. X-ray examination at this time (Fig. 21A) revealed marked posterior and downward slipping of both femoral heads. On the right side the epiphyseal plate had completely united; on the left side it was not completely obliterated.

On April 23, 1947, a wedge osteotomy through the neck of the left femur was performed. The head was reduced upon the neck and the fragments were held by means of a Smith-Petersen nail. A plaster spica was applied which was maintained for a period of three weeks. Five weeks postoperatively the child was allowed to be ambulatory, non-weight-bearing on the left lower extremity provided by means of crutches and an elevated shoe on the right.

The patient was last seen on July 30, 1947, three months post-operatively. She was still non-weight-bearing. She had had no symptoms referable to the right hip. Examination of the hips at this time revealed:

	Right	Left
Leg lengths.....	33½ inches	33½ inches
A.G.E.....	180 degrees	180 degrees
Range of flexion.....	110 degrees	100 degrees
Internal rotation.....	0 degrees	0 degrees
External rotation.....	40 degrees	40 degrees
Internal rotation in complete extension.....	20 degrees	30 degrees
Abduction.....	10 degrees	20 degrees
Adduction.....	20 degrees	20 degrees

X-ray examination (Fig. 21B) revealed no absorption about the nail and the epiphyseal lines were partly obliterated.

This case is too recent to evaluate; also,

the patient is to have a subtrochanteric osteotomy at a later date on the right hip. This is the procedure of choice rather than a wedge osteotomy because the epiphyseal plate has already closed and there are some early signs of degenerative changes in the right acetabulum.

#### SUMMARY

A presentation has been made of the varied forms of treatment of slipped femoral epiphysis in the marked stage, with a review of their end results as reported in the literature.

Except in acute cases with a very recent duration of symptoms, manipulation, with a record of uniformly poor results has been abandoned in most quarters.

Satisfactory results have been reported by some groups from reduction by traction in early cases, although it has been noted that strong traction may also compromise the blood supply of the femoral head.

In reviewing the surgical means of correcting this deformity it has been noted that since internal fixation has supplanted plaster immobilization, the results of open reduction with reposition of the head have been better. Groups still carrying out this procedure believe that the end results warrant continuation of the method.

Subtrochanteric osteotomy, reserved in most clinics for cases of long-standing and severe deformity, has produced, by and large, poor results.

The treatment herein presented of wedge osteotomy of the neck of the femur seems to be most rational because in these ad-

vanced cases we have apparently a disruption of the circulation of the head of the femur which at its best is inadequate, and apparently union has begun to take place in the deformed attitude with an attempt at normal restoration of circulation. Should one try to replace the head of the femur by division of the epiphyseal line, one would add trauma to the already impaired circulation of the head. The neck of the femur has an ample circulation; thus, by removal of a section of bone through the cancellous area, one has not disrupted the circulation of the impaired epiphyseal plate. By this method we have restored the anatomic position of the head of the femur, corrected the coxavara and given nature the best chance to aid us in the healing of the affected parts.

A series of cases of patients so treated at this hospital, twenty during the past ten years, have been presented and evaluated as to function and symptoms. The end results of these cases indicate that this method of treatment has a definite place in the armamentarium of the orthopedic surgeon treating these deformities.

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# TRANSPLANTATION OF AORTIC SEGMENTS FIXED IN 4 PER CENT NEUTRAL FORMALIN\*

## REPORT OF EXPERIMENTS IN DOGS

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THIS study was undertaken to determine whether or not live tissue was necessary for establishment of satisfactory aortic grafts. Although we have developed a method whereby blood vessel segments can be kept in a living state for four or five weeks and have demonstrated that these viable segments can be successfully used to bridge defects in the aorta,<sup>1,7</sup> the technic involves certain difficulties when it is employed for operations on humans. First, the blood vessels must be secured in a sterile manner, within a few hours after the donor's death; this time factor alone cuts down to a great extent the available supply of vessels. Second, storage of the material must be supervised and performed by experienced and trained personnel. Third, the longest period that these live vessels can be kept and used safely is about one month, at the end of which time any unused vessels must be discarded. It has become obvious that a blood-vessel bank (preserving *live* segments of vessels) is not practical except in a very few clinics where much fresh autopsy material is available for supplying the vessels and where a large volume of cardiovascular surgery is being performed.

We are now seeking to develop methods whereby vascular segments can be obtained under non-sterile conditions, can be stored in a simple manner for long periods of time and can be used as satisfactory vessel grafts. To reach this goal (if it is attainable) it will be necessary to devitalize the stored vessels. If it can be

shown that devitalized segments can be used to bridge arterial gaps successfully, it would then be possible for many hospitals or military establishments to keep on hand a supply of vessels which could be used whenever the need arises.

Formalin fixation of tissue was chosen for study because such treatment of a vessel obviously devitalizes it and because such fixation produces a vessel which is tough and strong. It is known that some satisfactory grafts have been carried out with formalin-fixed vessels in the past.<sup>2,3,5</sup> The tissue utilized in our series of grafts was, however, prepared in a different manner than any reported in the literature. While our failures have been numerous, many of the grafts have been so much more successful than anticipated that we believe it is desirable to publish a preliminary account of the results which we have observed.

### MATERIALS AND METHODS

Segments of thoracic aorta (2 to 10 cm. long) were removed from donor dogs, were freed of excess areolar tissue and their branches were ligated with 4-0 silk. These vessels were not obtained in an aseptic way. In most instances the segments were procured within two to three hours after death of the animal, but in some the period was much longer than this. The segments were washed free of blood and fixed for two to twenty-five days in a solution of 4 per cent formalin (in physiologic saline or in tap water). The solution was neutralized by adding an excess of commercial chalk or calcium carbonate (U.S.P.). In the latter part

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of the study the vessels were kept stretched over glass or plastic tubes while fixing them in the formalin. This served to maintain a lumen of desired size, to prevent wrinkling and to make a thinner wall which facilitated subsequent manipulations. Furthermore, such fixation over tubes allowed the vessel to be molded into a curved form when this was desired for certain types of grafts. (Fig. 1.)

Before implanting segments into recipient animals they were placed for periods of one to forty-eight hours in a small volume of a buffered, complex solution at pH 7.6.\* On the operating table the segment was kept in several hundred cc. of physiologic saline for one to two additional hours.

Formalin-fixed segments of aorta were implanted into two series of recipient animals. In the first group formalinized aortic grafts were inserted into the abdominal aortas of ten mongrel dogs, weighing from 25 to 40 pounds. The abdominal aorta between the renal and inferior mesenteric arteries was chosen as the site of implantation (Fig. 2A) so that the method of implantation would be uniform with other series of grafts carried out in this laboratory. The operative technic employed was similar to that reported in earlier papers.<sup>1,7</sup> The grafts measured 2 to 4 cm. in length, and each end was sewed into place by using a continuous, everting, mattress suture of 5-0 deknatel silk. The total time of aortic occlusion was generally thirty to forty-five minutes. No anticoagulants, intravenous fluids or other special care was given postoperatively. The dogs were subsequently studied by palpation of the femoral arteries and in four instances by diodrast aortography. Two of the animals were exercised several times a week on a treadmill, increasing the work performed until they were running as hard as fully trained

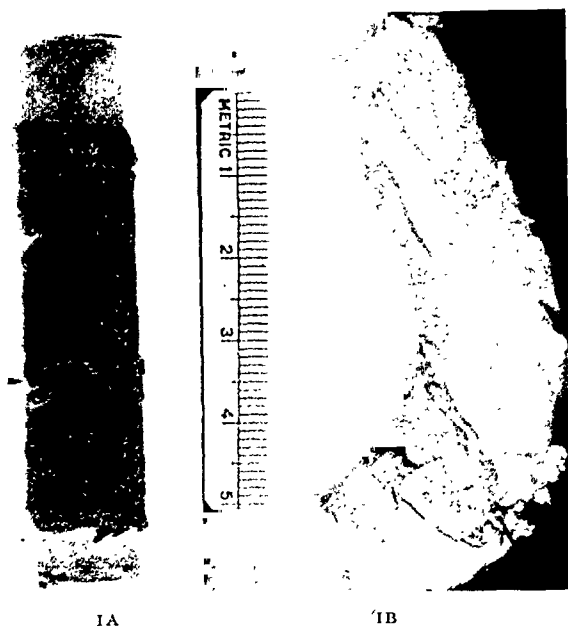


FIG. 1. Photographs of formalinized aortic segments. A, segment stretched over a polyethylene tube; B, segment after fixation over a bent glass rod.

normal dogs (i.e., five miles per hour up a 20 degree incline for twenty minutes). Autopsies were performed on all animals which died or were sacrificed and in most instances sections were taken for histologic study. These blocks were fixed in formalin, embedded in paraffin, and were stained with hematoxylin and eosine and with a combined Verhoeff and Van Giessen stain.

In the second series of graft implantations, formalin-preserved aortic segments were used in the production of extracardiac shunts in dogs. These shunts consisted of a channel on the exterior of the heart, connected in such a way as to circumvent one of the heart valves (hoping thereby to establish a pathway which could carry blood around an obstructed or stenosed valve). These channels were constructed by utilizing a segment of formalin-fixed aorta, to which was anastomosed a freshly secured, proximal portion of dog pulmonary artery or aorta with its included valve. These shunts were used to by-pass the mitral valve by inserting them between the left auricle and the left ventricle. (Fig. 2B.) They were also used to by-pass the pulmonary valve by inserting them between the right ventricle and the pulmonary artery. (Fig. 2C.) Finally, they were used to circumvent the aortic valve by introducing them between the left ventricle and the descending aorta. Sixty shunts were produced by these methods. Forty-five of

\*The balanced salt solution is a modification of Tyrode's solution prepared and supplied to us by Dr. J. H. Hanks.<sup>4</sup> It is made as follows: Stock solution, contents per 250 cc.: NaCl 20 Gm.; KCl 1 Gm.;  $MgSO_4 \cdot 7H_2O$  0.2 Gm.;  $MgCl_2 \cdot 6H_2O$  0.2 Gm.;  $CaCl_2$  0.35 Gm. (dissolved separately);  $Na_2HPO_4$  0.15 Gm. (0.38 Gm. of  $Na_2HPO_4 \cdot 12H_2O$ );  $KH_2PO_4$  0.15 Gm.; glucose 2.5 Gm.; 0.4 per cent phenol red 12.5 cc. Buffer: 1.4 per cent  $NaHCO_3$ . The stock solution is stored at room temperature with 1 cc. chloroform. The final solution is made by diluting the stock 1:10, autoclaving and adding 0.5 cc. buffer (previously autoclaved) per 20 cc. This is stored in cotton-stoppered containers in the icebox; it has an equilibrium at about pH 7.6.

these animals survived the operative procedure and lived from one day to four months. In twenty-two of the surviving dogs the main pulmonary artery or the ascending aorta was securely tied so that all of the circulating blood had to pass through the shunt. Observations

## OBSERVATIONS

Vessels fixed in formalin by the previously described method have a leathery quality and are very tough. The stiffness of such a fixed vessel makes it somewhat

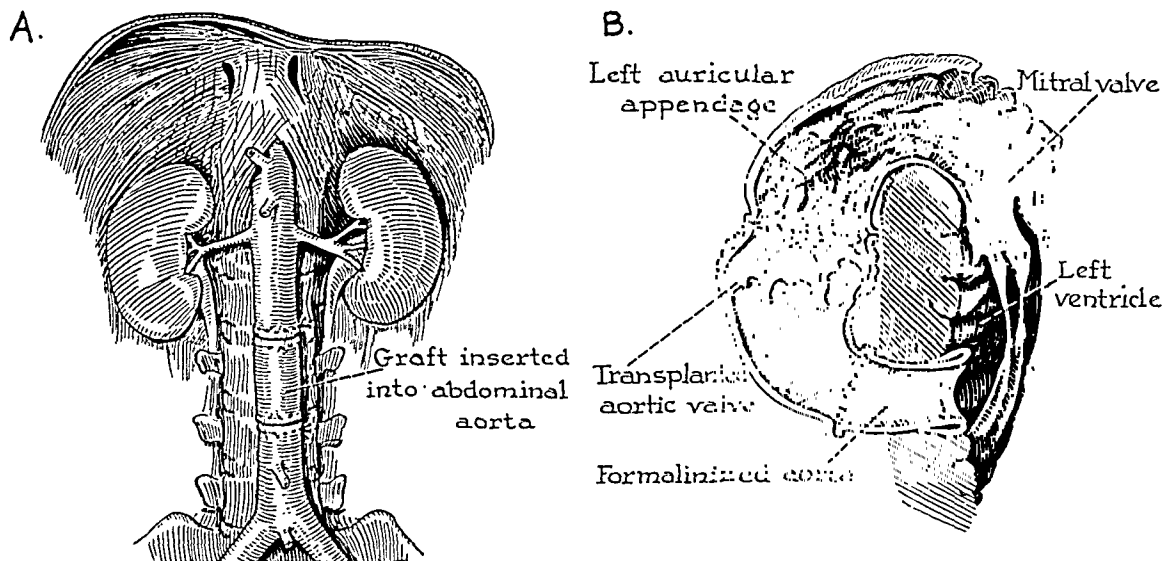


FIG. 2. A and B, methods of study by insertion of formalinized aortic segments. A, segment placed in abdominal aorta; B, formalinized segment used in construction of extracardiac shunt around mitral valve.

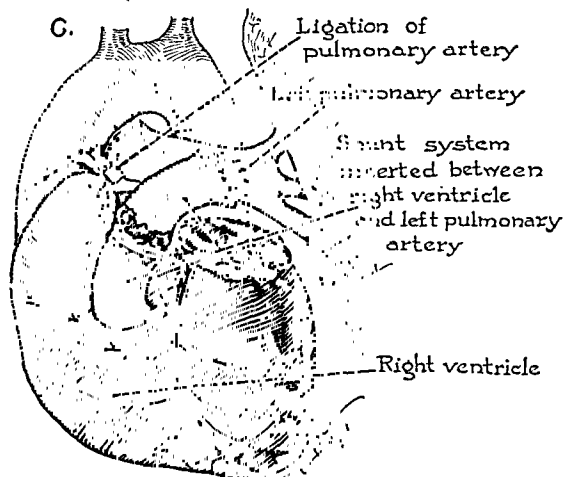


FIG. 2. C, formalinized segment used in forming extracardiac shunt around pulmonary valve. Host pulmonary artery tied off.

obtained from these dogs will be published in detail elsewhere. For the present communication we will list only the observations made upon the formalinized portions of these extracardiac shunts. All grafts were carefully examined grossly for intimal erosions, clots, rupture, dehiscence, calcification and firmness of union with the ventricular wall.

more troublesome to work with than is the case with fresh blood vessels. While they are less pliable than normal aortas, it is possible to sew them, to evert their ends and to make satisfactory anastomotic lines. The grafts prepared by fixing tissues over glass or plastic tubes have thinner walls, smoother intimas and are much easier to handle than those which are not stretched during the process of fixation.

There were no operative deaths in the series of experiments in which grafts were inserted into the abdominal aorta. The ten experiments are summarized in Table 1. One dog died of pneumonia two days after operation, and a second dog died fourteen days postoperatively as the result of a partial separation of his lower suture line. This disruption had apparently resulted from infection since an abscess was found around the suture line. Of the eight remaining dogs one is still under observation and seven have been sacrificed at periods ranging up to nine months after operations. All of the eight surviving animals

have had strong femoral arterial pulsations; aortic channels of adequate lumen have been demonstrated by arteriography in four of them. (Figs. 3 and 4.) The autopsied dogs have shown blood channels of adequate size, but some have exhibited

line. The two fourteen-day specimens were widely patent but one had a small separation at the lower suture line while the other had a very thin, film-like clot over the entire inner surface of the graft. The animal sacrificed at thirty days showed

TABLE I  
OBSERVATIONS ON ABDOMINAL AORTIC GRAFTS UTILIZING FORMALIN FIXED ARTERIAL SEGMENTS

Dog No.	Postoperative Period of Observation	Cause of Death	Aortic Channel by Aortagram	Gross Appearance at Autopsy	Microscopic Observations	Comments
131-48	2 days	Pneumonia	.....	Competent; small fresh mural thrombus on one suture line	.....	More pliable than at insertion
162-48	14 days	Infection* and hemorrhage	.....	Competent; small separation at lower suture line	.....	Breakdown probably due to infection
105-47	14 days	Sacrificed	.....	Competent; very thin clot over entire inner surface of the graft	Graft well preserved and covered with thick new adventitia; no regeneration of the intima within the graft	More pliable than at insertion
12-48	30 days	Sacrificed	.....	Competent; small mural thrombus of the host aorta	Loss of nuclear staining throughout; recent leakage of blood through intimal defect in the graft with formation of a false aneurysm between the graft and its new adventitia	Thrombus in the host aorta from crushing by the clamps
140-48	2½ months	Sacrificed	At two months fully patent; not dilated	Competent; suture lines smoothly covered with intima; calcification in the wall	No original cells remaining; elastic fibers well preserved; thick new intima and adventitia; calcification in the media	Carried blood effectively in spite of calcification of the media
226-47	3 months	Sacrificed	.....	Competent; heavy calcification in the wall; several small intimal erosions	Nonobstructive organized thrombus at the suture line; degeneration and focal ulceration of the original intima and inner portion of the media of the graft	Appeared to carry blood effectively
157-48	5 months	Still alive	.....	.....	.....	Strong femoral arterial pulsations
18-48	5½ months	Sacrificed	At one month and five months fully patent	Intima intact; lumen widely patent; no calcification by gross examination	New intact intima; acellular media; elastic tissue well preserved; new adventitia; no evidence of calcification	Excellent result both functionally and structurally
123-48	5½ months	Sacrificed	At three months fully patent	Competent; smooth intima; calcification in the wall	New intima; much calcium in the media	Good femoral pulsations; the dog reached maximum exercise tolerance
212-47	9 months	Sacrificed	At five months and nine months fully patent	Competent; intima smooth throughout; very heavy calcification in the wall	New intima; acellular and diffusely calcified media; elastic tissue fragmented	Carried blood effectively in spite of calcification; the dog reached maximum exercise tolerance

\* Abscess around the graft; hemorrhage from the suture line was the immediate cause of death.

† Calcification seen in the graft wall by roentgenogram.

important pathologic changes in the vessel walls.

The specimen from the dog which died (of pneumonia) two days postoperatively showed a competent vascular channel with a small mural thrombus on one suture

marked trauma to its abdominal aorta from the clamps which had been applied, with resulting formation of a mural thrombus in the host portion. The three-months' specimen showed small areas of intimal ulceration. In four specimens (removed at



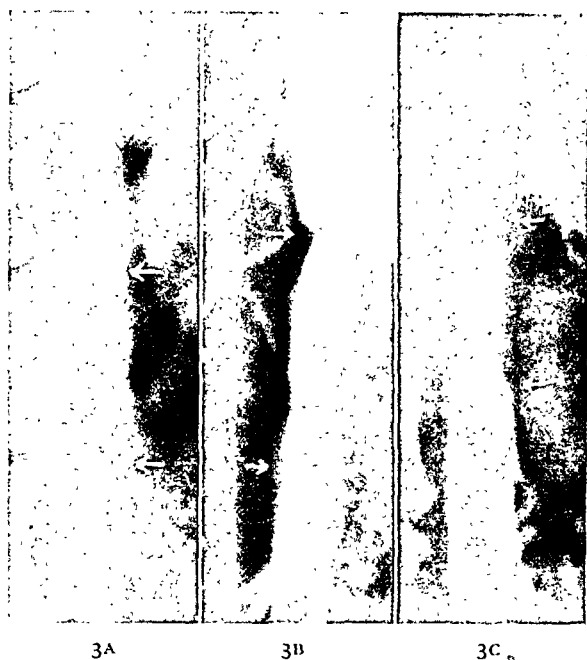


FIG. 3. Aortograms demonstrating patency of abdominal aortic grafts (indicated between arrows). There is some fibrosis and constriction of the grafts. A, graft in place for two months; B, graft in place for three months; C, graft in place for five months.

two and one-half, three, five and one-half and nine months) there was considerable calcification within the graft walls. In the nine-months' specimen calcification had been discovered by roentgenologic examination five months after operation. (Fig. 4.) In spite of the fact that calcification was extensive in some specimens in none of them was there aneurysmal dilatation, large surface erosions or clots. (Fig. 5.) One five and one-half-months' specimen showed no gross evidence of degenerative changes; the wall was quite soft and pliable and could not be distinguished from the adjacent normal host aorta.

Evaluation of the effect of strain on the abdominal grafts was considered to be important. Tests on two dogs (at four and seven months) showed no difficulty in bringing them to exercise levels which are considered to be maximum for normal animals. No vascular accidents ensued; this is particularly interesting since the grafts in both of them were heavily calcified.

For the first two weeks after transplanta-



FIG. 4. Observations on Dog, 212-47. A, catheter in abdominal aorta (introduced through femoral artery at nine months). Note calcification in wall of graft; B, aortogram showing adequate channel through graft (indicated between the arrows); C, roentgenogram of autopsy specimen showing intense calcification in wall of graft; D, autopsy specimen opened. The graft wall is very rigid because of its calcium content.

tion into the abdominal aorta the microscopic appearance of the media of the formalin-fixed grafts remained essentially unaltered. (Fig. 6.) Most of the original intima of the graft had disappeared by this time and where it persisted it was represented by a thin lamella of an amphophilic gel-like material containing occasional pyknotic nuclei of the original subendothelial fibrocytes, clusters of small clear vacuoles and occasional mononuclear wandering cells. Within two weeks the original adventitia and the attached tabs of adipose tissue were undergoing dissolution and were being penetrated by granulation tissue and wandering cells derived from the host. The entire graft at this time was surrounded by a zone of inflammatory reaction, the outstanding characteristic of which was proliferation of new fibrous connective tissue. Failure of the formalin-fixed tissue to elicit a harmful or destruc-

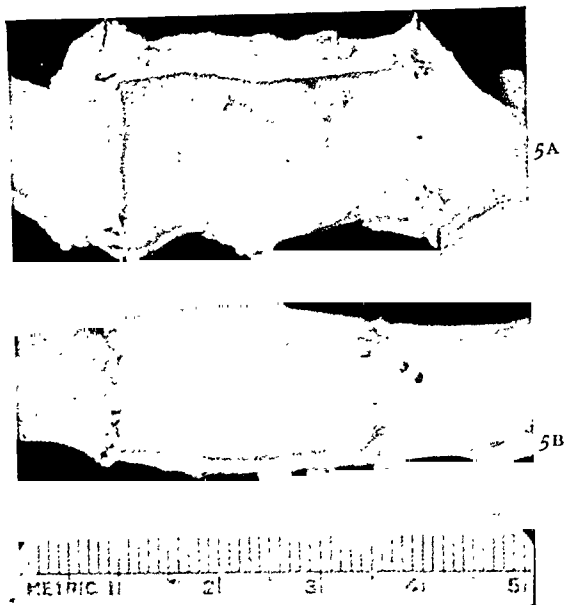


FIG. 5. Photographs of the better aortic channels produced by formalinized grafts. The intimas are smooth and there are no thrombi; there is good healing at suture lines. A, graft had been in place two and a half months; B, graft had been in place five and a half months.

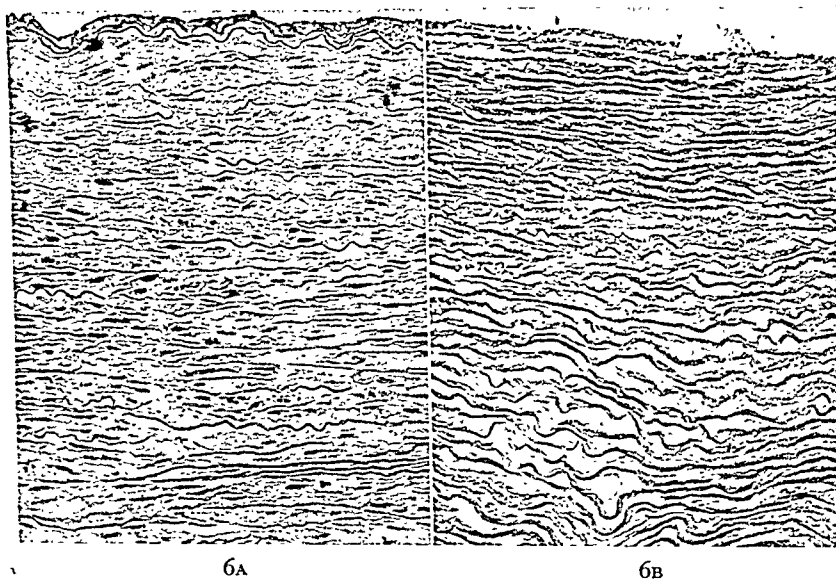


FIG. 6. Photomicrographs showing appearance of media of formalin-fixed grafts fourteen days (A) and thirty days (B) after transplantation into abdominal aorta (Verhoeff's elastic method). In (A) the elastic fibers and the smooth muscle cells appear relatively unaltered. In (B) the elastic fibers are slightly thickened but intact and the cellular components of the media have been converted into an homogeneous acidophilic gel.  $\times 140$ .

tive reaction on the part of the living tissue of the host was one of the most striking and surprising findings.

With the passage of time the graft acquired from its host a new intima and a

new adventitia. Even at two weeks the wedge-shaped irregularity at the suture line had been filled in by a pad of fibroblasts derived from the adjacent living intima. (Fig. 7.) With the passage of



FIG. 7. Photomicrograph through everted suture line of anastomosis of host aorta (right) to graft (left) after five months (Verhoeff's elastic method). The wedge-shaped irregularity in the lumen at the site of the anastomosis has been filled by proliferation of intima from the host.  $\times 42$ .

time and then became stabilized between five and six months. (Fig. 8.)

The cellular elements of the denatured media gradually disappeared (Fig. 6) and within two months the spaces between elastic fibers were occupied by a homogeneous acidophilic material containing a finely dispersed precipitate of calcium salts. This precipitation of calcium occurred first and with greatest density immediately adjacent to the elastic fibers. The elastic fibers themselves became thicker with the passage of time and after three months showed

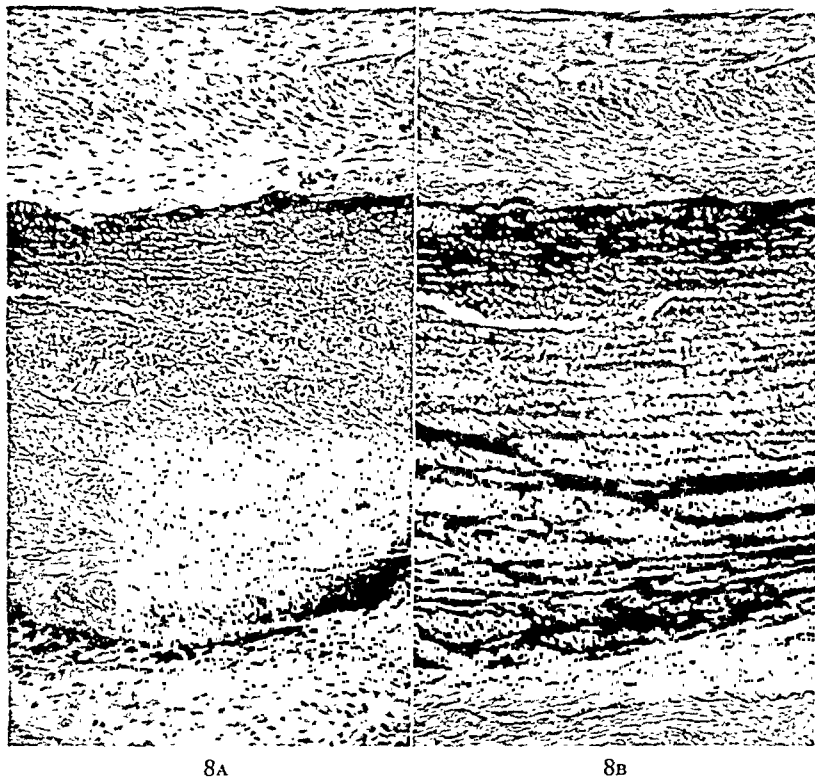


FIG. 8. Photomicrographs ( $\times 115$ ) of formalin-fixed aortic graft after nine months. Section (A) stained by hematoxylin and eosin and section (B) by the Verhoeff method were cut from the same block. In (A) it may be seen that the original graft is extensively calcified. The coarser granules have the appearance of nuclei but are actually calcified elastic fibers. In (B) the swollen but for the most part still intact elastic fibers of the original graft are conspicuous. The graft has become lined with a thick and compact new intima and surrounded by a dense sheath of new fibrous connective tissue.

months a pannus of fibroblasts covered by endothelium grew in from each end to line the graft. There was no evidence, however, that either smooth muscle cells or elastic fibers were formed in the intima which became progressively thicker for a

some tendency toward fragmentation. That the deterioration of the formalin-denatured elastic tissue occurs very slowly is indicated by the persistence even after nine months of the original media at approximately two-thirds of its original thickness. Its loss in



FIG. 9. Photographs showing excellent healing of formalinized aortic segments to ventricular walls through which they were inserted to form extracardiac shunts. A, shunt around mitral valve after five days; L. A., left auricle; S., shunt, L. V., left ventricle. Note the excellent union of the shunt system to the left ventricular wall. B, shunt from right ventricle to pulmonary artery after three and a half months; R. V., right ventricle; S., formalinized portion of shunt. Note the patency of the shunt and the firm union between the shunt and right ventricular wall.

thickness is apparently due in part to peripheral absorption by the living tissues of the new intima and the new adventitia and in part to a condensation of the interlamellar remains of the smooth muscle.

The most striking and functionally important adaptations made by the host to the formalin-fixed graft were: (1) laying down of an exceedingly dense and thick adventitia and (2) formation of a new intima of living cells. For many months after transplantation of the graft there was evidence of a low grade exudative inflammatory reaction at the junction of the dead and the living tissue. This reaction became progressively less pronounced as the months elapsed and after five months the junction between the heavy collagen fibers laid down by the host and the formalinized collagen and elastic fibers of the graft could not be recognized with certainty. It appeared that endothelialization of the graft was perhaps less important to its success than was the adventitial proliferation. A graft may continue to conduct blood and to remain free of thrombus formation even though its inner surface is

not lined by living cells. To remain intact at the suture lines and to resist dilatation it is essential that a new and competent adventitia be laid down, and this was accomplished.

In the sixty instances in which formalinized aortic segments were used in the production of extracardiac shunts the formalinized tissue presented but few difficulties in manipulation. In all cases the preserved segment was inserted through the ventricular wall, to which it was joined. Without exception the cardiac musculature united rapidly and firmly to the formalinized vessel. (Fig. 9.) In no case did the formalinized segment thrombose, rupture or show gross calcification in its wall. It is important to emphasize that in twenty-two of the animals all of the circulating blood had been passing through the shunt for periods varying from one day to four months. The usual period of observation was only one or two weeks.

#### COMMENT

Several reports of arterial grafts with formalin-fixed tissue have been presented

in the older literature.<sup>2,3,5,6</sup> The largest series, consisting of five abdominal aortic grafts, is that of Levin and Larkin.<sup>6</sup> Two dogs died within two days of "paralysis," the grafts being well preserved. Two died at about ten days with competent vascular channels, but the grafts showed considerable loss of nuclear staining and a marked fibrotic reaction about them. The fifth dog was sacrificed at ten weeks and an occluding thrombus was found. In this instance the graft showed zones of calcified material, resorption and almost complete sequestration. These authors believed that new connective tissue would not grow on the old framework. The end result of a formalin-fixed carotid graft was reported by Guthrie<sup>3</sup> in 1919. This graft, eleven years after initial implantation, persisted as a hollow, greatly fibrosed piece of tissue.

In general, the methods of fixation used by the older writers consisted of the following: The tissue was immersed for a period of time in 4 per cent formalin, which is an acid solution. It was then treated with ammonia for neutralization, and run up to absolute alcohol and treated with paraffin before implantation. In most instances the tissue implanted must have been quite irritating, and it is not surprising that actual sequestration was sometimes observed. We have endeavored to preserve vessels in such a way that irritation to a host animal is minimized. We hoped to accomplish this by using neutral formalin for the fixative and then washing the aortic segment before implantation by placing it in a buffered salt solution of a pH near neutral. While fixation of the aorta in 4 per cent neutral formalin obviously kills the tissue, it apparently does not interfere with development of a new intima and adventitia from the host.

Despite the occurrence of degenerative changes in a high percentage of the transplants to the abdominal aorta the fact remains that all served as adequate vascular channels for the periods of time during which the experiments were conducted. In the specimens from the two dogs brought

to maximum exercise tolerance at four and seven months, respectively, there was no aneurysmal dilatation and there were no gross or microscopic changes which had not been observed in the unexercised animals. Diffuse medial calcification was observed in four of the five older grafts and although there is no evidence that this mineralization impaired their functional usefulness it is possible that longer periods of post-transplantation observation would have disclosed instances of thrombosis or aneurysmal formation.

It is not the intention of this communication to leave the impression that grafting with formalin-fixed vessels is a method which can readily be applied to human cases. The purpose of the paper is merely to report our observations in this field of vascular experimentation. At the present time additional studies with other methods of vessel preservation are being carried out, with the objective of finding the one which would be most suitable for use in humans.

It is intriguing to think of the possibility of having a supply of arterial segments which could be used for grafting in humans—provided that the method of preservation is simple. It is possible that formalin-fixed vessels can be used in this manner with safety to bridge defects in large arteries such as the aorta. While our results of animal grafting with formalinized segments have not been as satisfactory as those in which viable grafts were used, many of our experiments have been so encouraging that further experimental work along this line is certainly justified.\*

\* After submitting the present manuscript for publication, twenty-seven additional formalin grafts have been inserted into recipient dogs, the grafts having been fixed in solutions of different pH values of 5.0, 6.0, 7.0, 7.2, 7.8 and 8.0. Grafts which had been kept in formalin at 7.8 and 8.0 were soft and almost useless; when implanted into the aortas of recipient dogs, death occurred in most instances from disruption of the grafts. In contrast, grafts which had been preserved in other formalin media with pH ranges from 5.0 to 7.2 were reasonably tough and they did not disrupt when implanted into recipient animals; furthermore, on preliminary observations they seem to have accumulated less calcium in their walls (up to seven months' period of observation) than did the grafts preserved in neutral formalin which are described in the present publication.

## SUMMARY

Arterial segments preserved in 4 per cent neutral formalin were used in ten dogs for abdominal aortic grafts. Vascular channels of satisfactory size resulted in all experiments. There was one instance of suture disruption (secondary to infection). Dogs have been kept as long as nine months after implantation of such aortic grafts. The grafts showed no tendency to dilate even under the stress of forced vigorous exercise. The most disturbing changes that have been observed in these grafts were degeneration of the media (fragmentation of elastica and calcification). The formalinized segment appears to act as a framework, along which a new intima and adventitia is laid down by the host.

The same type of preserved aortic segments have been used to enter and join with the ventricle in sixty instances in the production of extracardiac shunts in dogs; forty-five of these survived operation and were observed for short periods of time. There was no instance of thrombus originating in the formalinized segment, nor was there any rupture or calcification in this series. In animals observed for sufficiently long periods of time firm union could always be demonstrated between the formalinized vessel and the ventricular wall.

From these preliminary experiments it is believed that it might be possible to keep

formalinized human aortic segments and use them in human subjects if circumstances demand the immediate bridging of an aortic gap and no other graft more suitable (such as a fresh one) is available. While no final evaluation of this method of grafting can be made at the present time, the experimental observations to date justify additional studies to determine the ultimate fate of such grafts. It is a fact that when employed as grafts formalinized vessels do not stand up as well as fresh ones.

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# EVOLUTION OF MEDULLARY FIXATION OF FRACTURES BY THE LONGITUDINAL PIN\*

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IN 1942 the lay press (Time magazine) first aroused American interest in the principle of fixation of fractures by the longitudinal pin by presenting it in a news story as a medical mystery. In x-raying an old femoral fracture of an American soldier who had returned from Germany to England General Hospital, the American doctors, according to the story, were surprised to find the soldier carrying lengthwise in the medullary canal of his femur a long nail or bar. The soldier's story was that his femur had been fractured and that after it was mended in this manner he wore no cast and was immediately ambulatory.

Although the principle had been advocated in American literature several years previously<sup>1,2</sup> and exhibited before the Southern Medical Association in 1937, it appears that the popularization of the method has received its greatest impetus in Central Europe and the Scandinavian countries since 1940. In France interest was aroused in the method by persons returning home from Germany carrying the pins in their bones. A great many operations of this type were done in the closing years of the war and upon displaced persons after the war.

A fairly large literature on the subject has developed mostly in foreign journals and several types of nails, pins or bars have been suggested for this purpose. It appears that more than a thousand patients have been treated successfully by this method and those men reporting them have been universally enthusiastic about its future possibilities.

Our experience with this method covers a period of twelve years. Originally we

believed that the longitudinal pin was indicated only in certain selected cases in which the orthodox methods were not adequate. This was largely due to the fact that a satisfactory pin had not been developed. In the past year we have been able to develop a pin so versatile that we have found it applicable to practically all of the long bones of the body and we now believe that it is indicated in a large variety of fractures.

This work has been motivated by a desire to eliminate the need for plaster casts in fracture treatment. The aim has been to develop a type of internal fixation which would splint a broken bone while leaving the extremity free for function, permitting the patient to be ambulatory. The method utilizes the marrow cavity of the bone for transfixing the fracture by passing a stainless steel pin lengthwise within the bone for almost the entire length of the shaft. The fracture is exposed and reduced visually. Reduction is accomplished and maintained by passing the longitudinal pin through a drill hole in the extremity of the bone, driving it axially down the medullary canal, thence across the line of the reduced fracture and well into the distal fragment.

## EVOLUTION OF THE LONGITUDINAL PIN

The first case of which we have knowledge in which this type of fixation was used was in 1936 at which time we were forced by necessity to improvise the method in order to fix a compound Monteggia fracture of the elbow adequately (Fig. 1.) In this case the proximal third of the ulna was badly fragmented and the head of the radius was dislocated anter-

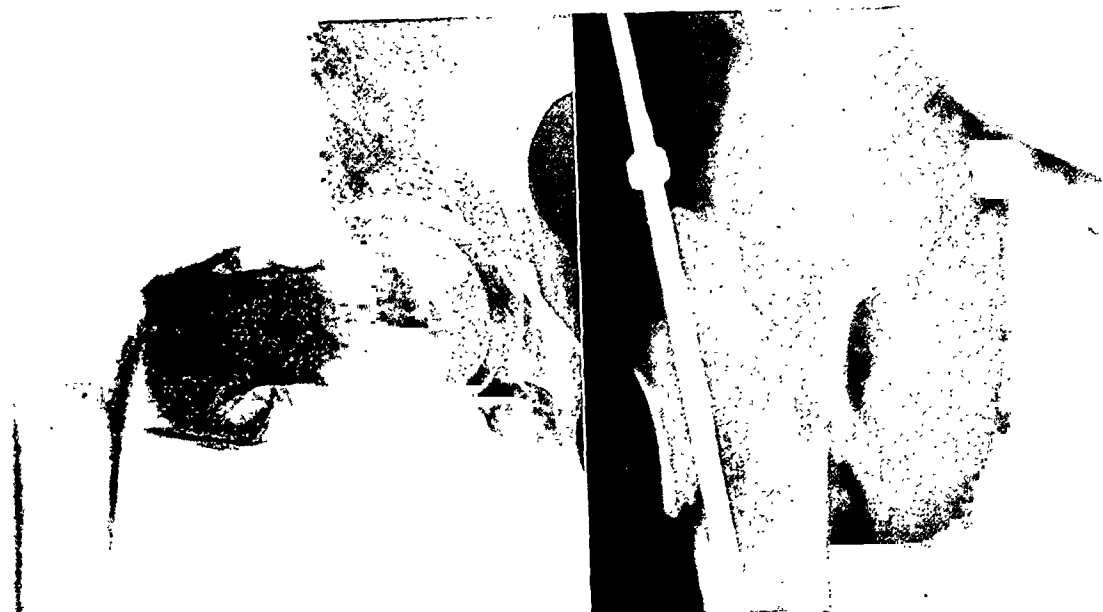
\* From the Department of Surgery, Rush Memorial Hospital, Meridian, Miss.



1A

1B

FIG. 1. A, original case. Severe Monteggia fracture of the elbow; B, after fixation by longitudinal Steinmann pin and stainless steel wires. (*Am. J. Surg.*, 1937.)



2A

2B

FIG. 2. A, subtrochanteric fracture of femur with marked displacement; B, after longitudinal pin fixation (old type). (From RUSH, LESLIE V. and RUSH, H. LOWRY. A technique for longitudinal pin fixation of certain fractures of the ulna and of the femur. *J. Bone & Joint Surg.*, 21: 619-626, 1939.)

iorly. A Steinmann pin was used in the ulna to re-align the olecranon with the distal shaft. This left a marked gap of about 2 inches between the main fragments. The continuity of the bone was re-established by wrapping the bone fragments about the pin in the intervening gap, fixing them in place with encircling stainless steel wires. This experience was recorded in 1937 in *The American Journal of Surgery*. It was pointed out that not only did rigid fixation of the ulna result but the reduction of the anteriorly dis-

located radial head was maintained by the procedure.

Several other cases presented themselves in which patients were treated in similar fashion and in all cases, for fear that the pin would migrate into the bone, the proximal end of the pin was permitted to emit through the skin and was wrapped with adhesive tape. In 1938 the method had been used on the upper portion of the shaft of the femur and in 1939 we reported additional cases<sup>2</sup> in which the pin had been used in the ulna and subtrochanteric





FIG. 3. A, three week old fracture neck of humerus with malposition.  $\times 16$ .

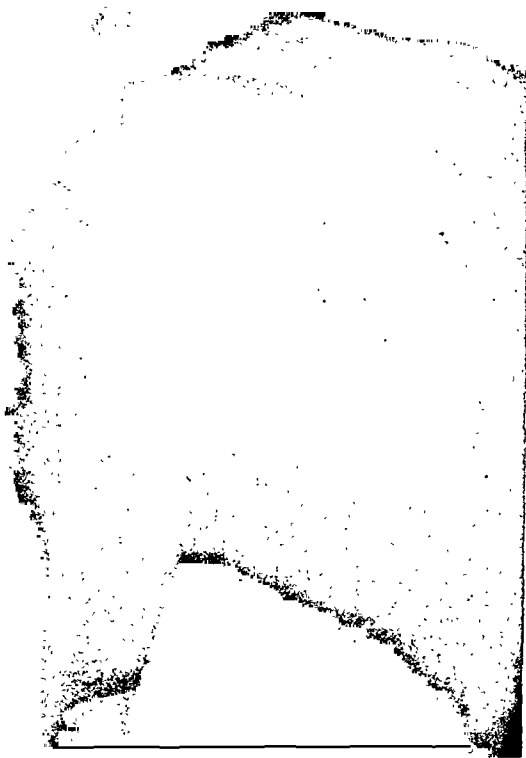


FIG. 3. B, after temporary fixation by longitudinal pin (old type). The head of the pin emitted through the skin and was removed in three weeks.

fracture of the femur. (Fig. 2.) At this time we described a new pin which was made of round rod, pointed as the Stein-

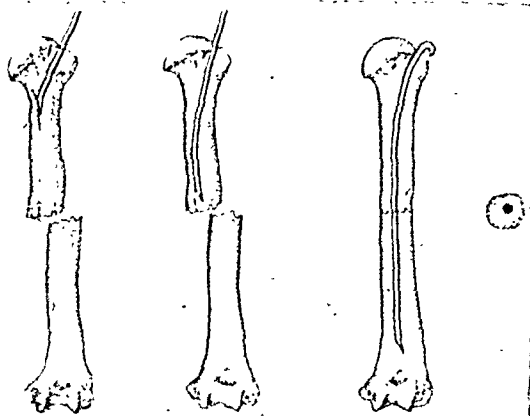


FIG. 4. Diagrammatic drawing showing how sled runner point aids in directing the pin down the medullary canal of a long bone.

mann pin, but with a collar at the proximal extremity to prevent its migration into the bone. This pin was introduced by means of a drill. During 1938 and 1939 several fractures of the upper third of the humerus were treated by this method, always permitting the pin to emit through the soft tissues. (Fig. 3.) Almost simultaneously Kirschner wires were used longitudinally in the clavicle.

Further experiences established the fact that the pin could best be directed by a mallet rather than a drill and that the point of the Steinmann pin did not lend itself well to introduction into the medullary cavity. It was also believed that the head of the pin should be buried beneath the soft tissues but should be so constructed that it could not migrate into the bone. It was further thought desirable that the pin be so constructed that it could be introduced into or withdrawn from the bone without the need for special instruments. It was difficult to direct the diamond-pointed pin into the medullary canal because of its tendency to penetrate the opposite cortex and enter the soft tissues rather than traverse the medullary canal. Several years had to pass before such a pin was developed.

Finally, in an effort to overcome these deficiencies we designed and recently described<sup>3</sup> a set of pins made of round, stainless steel rods. These pins are all

straight and of identical construction varying only in diameter and length. The point is shaped like a sled runner and assures its accurate direction down the medullary canal. (Fig. 4.) The shaft of the pin can be curved as the need indicates in the operating room by the use of a bending iron. There is a hooked, rounded head to prevent migration which permits the pin to be driven into the bone with the mallet from either the extremity or lateral surface of the bone. When the pin is driven into the bone for a sufficient depth, only a small, rounded knob extrudes which is not irritating to the soft tissues even in superficial locations. It permits removal simply by inserting the tip of a screw driver beneath the hooked head and tapping the pin out.

Kuntscher of Kiel, Germany,<sup>4</sup> in 1940 devised a nail and armamentarium for this purpose and great impetus was given the method by the availability of these nails to the profession. The nail devised by Kuntscher is U-shaped in cross section. The point is beveled on one side to facilitate the introduction of the nail into the medullary canal. At the proximal end of the shaft, however, there is no head or collar to prevent migration of the nail into the bone. It has the disadvantage of requiring special instruments for its introduction and extraction from the bone. The U construction precludes shaping in the operating room, making it necessary for the surgeon to have a variety of pins not only of various lengths but of various curves, depending on the bone to be operated upon.

Street, Hansen and Brewer<sup>5</sup> in 1946 described straight, diamond-shaped bars for use in the femur and humerus. Recently Westerborn<sup>6</sup> of Sweden described a nail similar to the Kuntscher nail which is flanged at the proximal extremity.

All of these nails project into the soft tissues at the extremity of the bone to provide for removal. They all require special apparatus for the introduction and extraction. Furthermore, they are designed to be

driven tightly into the medullary canal, being designed to traverse completely the width of the canal. We have found that sufficient rigidity can be secured without jamming the marrow cavity and believe that in addition the longitudinal muscles should be allowed free play to compress the fractured bone ends.

#### INDICATIONS

Now in the upper extremity it is possible to fix the clavicle, the entire humeral shaft, entire shaft of the radius and ulna and the metacarpals (Fig. 5.) In the lower extremity the upper two-thirds of the femur are very amenable to this method and probably provide its greatest indication. In the lower third of the femur the medullary canal is wide; the satisfactory technic for pinning this region has not yet been devised. However, in one case we were able to secure satisfactory fixation by passing a curved pin upward into the shaft from a point of entrance at the internal epicondyle. Double pins, one from each condyle, might be the answer.

The medullary canal of the tibia is narrow in its middle half and very secure fixation can be accomplished in this region. The canal widens toward the knee and ankle making fixation in the proximal and distal portions of the tibial shaft less secure. In one instance we secured reasonably good fixation in the lower third of the tibia by passing a curved pin upward from a point of entrance at the internal malleolus.

Complex fractures of the ankle offer a beautiful field for this procedure. (Fig. 6.) Very splendid results have been secured in three cases by passing the pin upward in the fibula from the point of entrance at the tip of the external malleolus using short pins in the internal malleolus.

There have been a great many compound fractures in this group which have been treated in this manner. There have been no infections and the pin was well tolerated in these cases. It has proven a considerable adjunct and is now used almost routinely.

The primary indication is in transverse fractures when no additional fixation is necessary. It alone has been found ade-

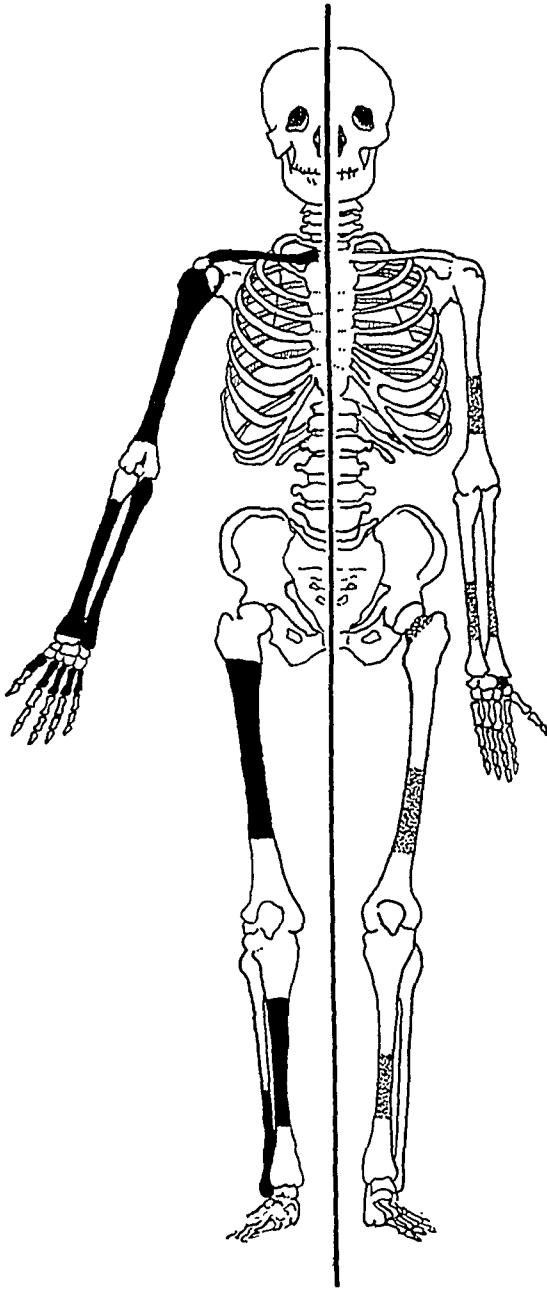


FIG. 5. Comparative sketch showing usefulness of pin in preventing non-union. Dotted areas indicate regions in which non-union is frequent. Black areas show regions in which pin is indicated.

quate in certain spiral, oblique and comminuted fractures. (Fig. 7.) When there is much tendency to lateral displacement of fragments, the use of encircling stainless

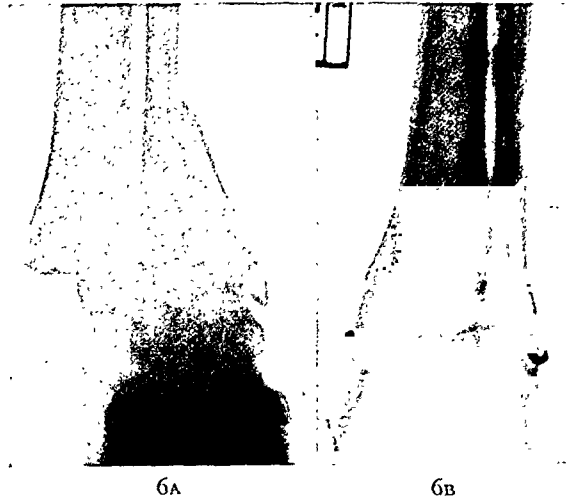


FIG. 6. A, complex ankle fracture with severe soft part damage; B, anteroposterior view six weeks after pinning. Ankle immobilized two weeks; excellent function and full weight-bearing six weeks.

steel wires or transverse bolts have been found an advantage. The use of screws is contraindicated in most instances as they are not compatible with the physiology of the principle.

In multiple fractures it has been found that the bone can be rigidly re-aligned by threading the fragments upon the pin-like beads upon a string. In severely comminuted fractures when the major fragments have been re-aligned upon the pin the minor fragments can often be wrapped about the pin with encircling stainless steel wires to restore the continuity of the bone.

*Practicability.* The method entails essential open reduction. We have used the blind method under fluoroscopic or x-ray control on the humerus and femur and tibia but do not recommend it as a general procedure. Like other forms of open fixation, a reasonable familiarity with the method is essential to its facile application. After this acquaintance has been established, the longitudinal pin will be found much simpler and quicker of application than bone plates. Subperiosteal dissection is unnecessary but a small incision is needed to permit freeing and aligning the bone ends. Soft tissue trauma is minimized and the bone ends are not insulted. The passage

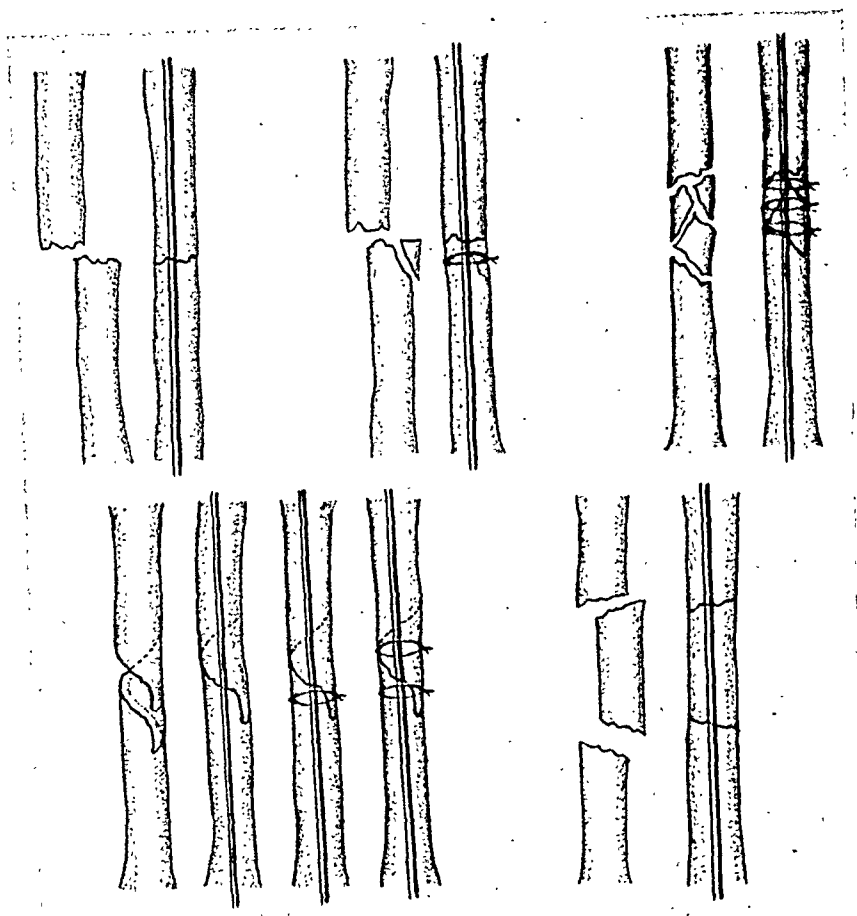


FIG. 7. Diagrammatic drawing showing methods of using the pin in various types of fractures.

of the pin concomitant with the reduction often simplifies the procedure.

Unlike plate fixation, distraction of the bone ends does not occur. The longitudinal muscle pull in other types of treatment is a major factor to reckon with. In longitudinal pin fixation it becomes the surgeon's ally. We have found it unnecessary to jam the pin in the canal and, consequently, there is no occasion for the cortex to split. The bone is free to glide upon the pin. Even though absorption of the bone ends occurs, and it does normally occur in the process of healing, constant snug approximation is maintained by this muscle pull.

Operative time is reduced by the simplicity of the technic. Furthermore, at the completion of the operation the patient does not have to submit to a prolongation of the anesthetic for the application of a large plaster cast.

*Safety.* In this series of cases which is consecutive there were no infections and no deaths. Although a large number of the operations were done prior to the advent of sulfa drugs and penicillin and many of the extremities were badly compounded with extensive soft tissue damage, the simplicity of the technic and the opportunity for early ambulation made it applicable for aged individuals and bad risks. We have seen no harmful effects from the pin when proper metal was used. These patients have been x-rayed frequently and observed closely. There has been no evidence of bone absorption nor crippling of the blood supply of the bone. Neither has there been evidence of anemia or embolism. The oldest patient upon whom it has been used was a seventy-nine year old woman with a fracture of the femoral shaft.

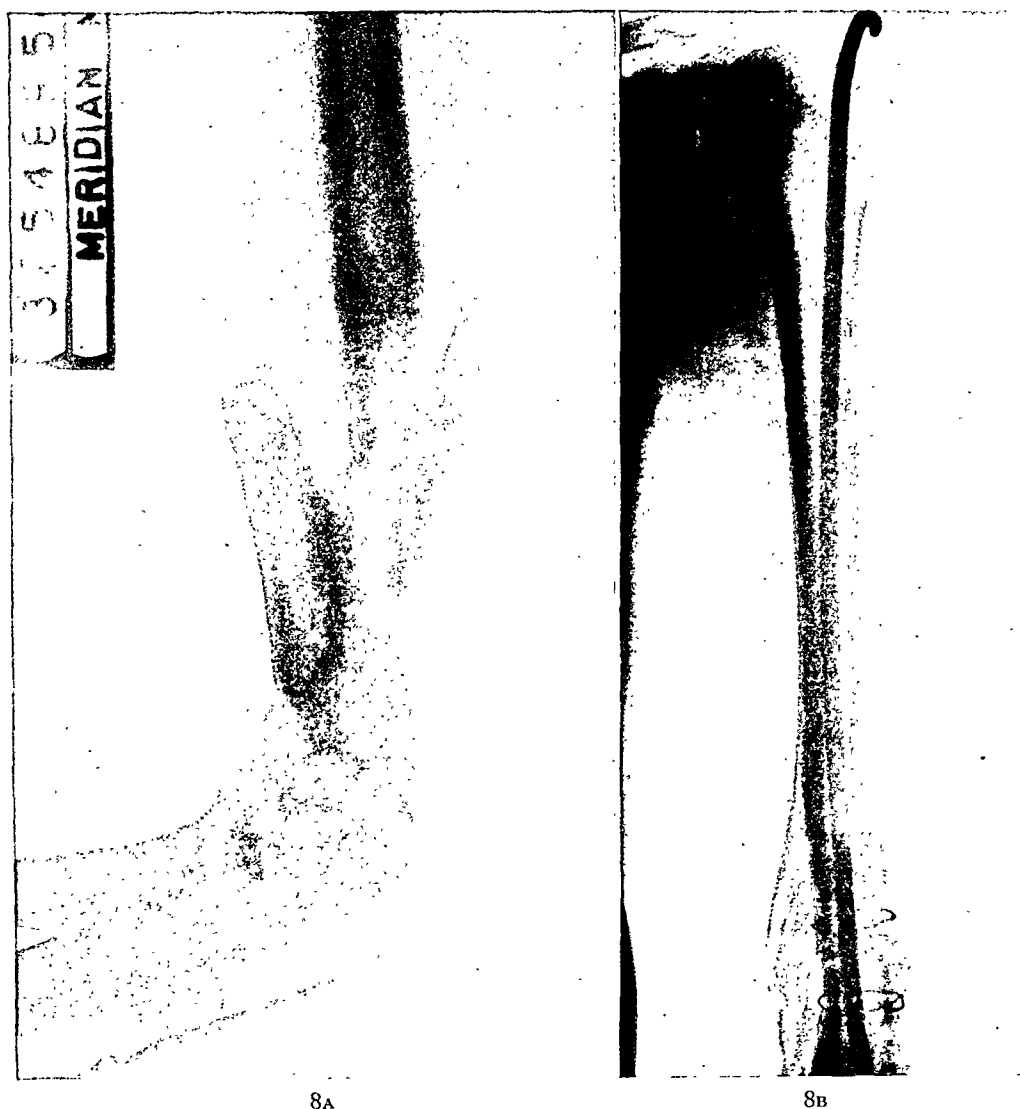


FIG. 8. A, comminuted fracture lower third of humerus; B, anteroposterior view showing the extensive callus three weeks after introduction of pin.

#### CONTRIBUTIONS TO RECOVERY

In fractures of the clavicle this method has been used in only seven cases because we have believed that open reduction was rarely indicated in clavicle fractures. In all clavicle cases the fixation has been secure and full range of motion of the shoulder has been comfortably possible within a few days after surgery. This marvelous comfort and the extremely short period of disability that has been observed suggests that the method might be used much oftener in the future.

In the humerus and forearm, function

can be begun immediately. (Fig. 8.) Torque is not a consideration here. In the forearm a splint or cast might rarely be considered necessary to prevent dorsal bowing but in the humerus no external splinting is necessary and joint stiffness and muscle atrophy are not permitted to occur. In Colles' fracture, fixation is absolute and motion is immediately resumed.

In the metacarpals our experience has been limited to two cases. Splints were not used and function was begun immediately. Stiffness of the fingers was avoided and no dorsal bowing occurred. Union was rapid.

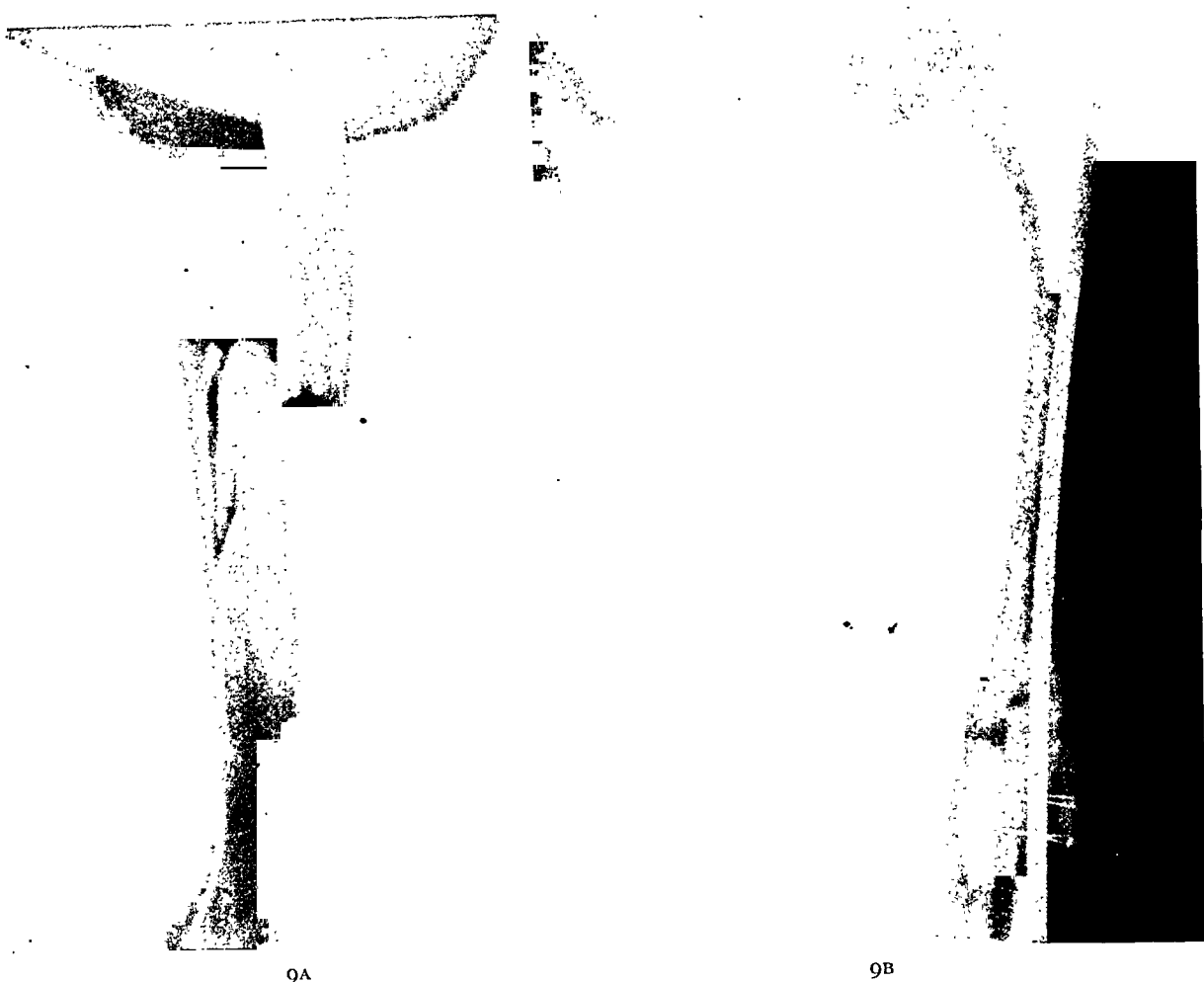


FIG. 9. A, comminuted fracture of shaft of femur before reduction; B, anteroposterior view six weeks after fixation by longitudinal pin and circular wires; no cast. Patient ambulatory on crutches in ten days; full weight-bearing in six weeks.

In the upper two-thirds of the femoral shaft, fixation is excellent aided by the pull of the adductor muscles. (Fig. 9.) No form of immobilization is necessary except in fractures at the trochanters in elderly individuals. It has been found that the trochanteric region in these elderly patients is brittle and the pin does not hold securely in the proximal fragment but does hold securely in young adults.

External rotation of the lower fragment of the femur has been given considerable thought. Rotation occurs only in those patients who remain recumbent for a long period of time and is caused by the weight of the foot turning the lower fragment outward. External rotation is limited but not completely prevented by the penetration of

the sled runner point into the cancellous bone at the lower end of the femur and by the point's being forced against the wall of the bone by muscle pull. Moderate external rotation occurred in one instance in a patient who was mentally below par and remained in bed for two months after being ambulatory in the hospital. Keeping the knee flexed for the first two weeks while recumbent has been the only measure instituted to prevent rotation and twenty-two patients were so treated; in no other instance did this deformity occur.

The medullary canal of the femur is larger than the pin and some lateral mobility of the fragments can be felt for the first few days after the operation. This sensation disappears by the twelfth day. Mo-



FIG. 10. A, anteroposterior view showing comminuted fracture mid-third of tibia; B, lateral view showing good union three months after pinning. Walking cast was used for six weeks.

tion is permitted as soon as the soreness will permit; the femur cases were routinely ambulatory on crutches within ten days and partial weight-bearing was permitted within two weeks.

In those cases in which the pin emitted for some distance above the great trochanters into the soft tissues, some irritation occurred but with the new type pin driven flush with the bone, this disagreeable feature has been eliminated.

It is difficult to control external rotation in the tibia by the pin alone and for this reason in fractures of the shaft a walking cast is routinely applied when the sutures are removed. It is well to curve the pin slightly about 2 inches proximal to the point, with the convexity backward when using it in the tibia to prevent forward angulation and to limit torque. (Fig. 10.) While in the process of healing, the tibia does not throw out callus as prolifically as

does the humerus and femur. It has been definitely observed that healing is expedited by this procedure. In the ankle, fixation is usually secure and plaster casts appear unnecessary unless there is diastasis of the tibia and fibula. In three cases in which patients were operated upon full weight-bearing was possible within six weeks.

Plaster casts are not employed routinely in most operations upon the extremities. To control swelling a compression bandage of elastoplast is applied from the fingers or toes well up above the region operated upon. External plaster splints are frequently molded upon the surface of the elastoplast to immobilize the soft tissues until the period of reaction has subsided and healing of the soft tissues is well under way.

In reviewing our experiences we are impressed by the fact that this method has advanced considerably but it is still in its developmental stage. In properly selected cases it has contributed splendidly to the comfort and rapid recovery of the patient and we believe it possesses great potentialities.\*

\* Since this article was written it has come to our attention that Lambotte of Belgium in 1907 used an axial wire for fixation of a clavicle fracture and that in 1919 Hey Groves of England used an axial pipe for fixation of a subtrochanteric fracture of the femur. The series of cases in which this method has been used is now greatly in excess of 100. Double pins have been used successfully for the fixation of fractures of the lower third of the femur, the lower end of the humerus and both the proximal and distal extremities of the tibia.

The oldest patient upon whom this method has been used is an eighty-seven year old woman with a Colles' fracture.

One infection occurred in an old, previously infected compound fracture of the radius with non-union. This infection was controlled satisfactorily by chemotherapy. It was not necessary to remove the pin which proved to be a considerable adjunct in the treatment of the infection.

These pins are now made of Type 316 stainless steel; in no case in which this particular alloy has been used has evidence of corrosion yet been observed. Because this metal is soft, it was necessary in certain early cases to use Martensitic alloys in order to secure sufficient temper. In three instances corrosion of the metal did occur with some bone irritation which cleared up upon removal of the pin.

We wish to express appreciation to the Research

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Department of the Armco Steel Corporation for developing for us a specially hardened Type 316 stainless steel which possesses the qualities of both resilience and malleability which are essential qualities in the successful application of this method.



*Erratum:* The authors of "Brachial Plexus Block Anesthesia" which appeared in our July 1949 issue wish to call attention to an error in percentage which was overlooked in their proofs. On page 65 of this article in the first paragraph the last sentence should have read "Clinical findings in the comparison of 2 per cent procaine, 1.5 per cent metycaine and 0.15 per cent pontocaine, etc." The per cent of pontocaine should not have been 6.15 as printed.



# TREATMENT OF INGUINAL HERNIA

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SEVERAL factors may be responsible for the recurrence of an inguinal hernia, and of these the selection of operation is less important than the careful execution of the individual steps of a chosen procedure.

It is unfortunate that we tend to approach this problem with the idea of applying a method, since the weakness which exists in a large percentage of cases is extremely variable and the extent of this weakness cannot be definitely determined until after exposure of the inguinal canal. This attitude is, therefore, comparable to undertaking the repair of a leaky roof without being certain of the extent of the damage, its exact location and with little knowledge of the available materials for restoring the structural defect.

Evidence of lack of judgment in selecting a method is the fact that many still persist in employing the Bassini type of operation for routine repair of indirect hernia even though there is no weakness of the floor. The reason it has had even fair success is that in removing the sac one of the fundamentals of treatment has been adhered to.

If fundamental principles are disregarded, trouble is invited at the outset. Suturing under tension especially is to be avoided since it creates a bridge which is essentially weak and the tissue trauma, with which it is associated, weakens other supporting structures. Strangulation of tissue by constricting sutures, undue trauma and careless hemostasis contribute to a poor result.

In our opinion the choice of suture material is a secondary consideration although the trend is definitely toward the non-absorbable type. We have employed cotton over a period of years and have

had no complications or other reasons to regret its use. If there is undue stress from straining, vomiting or coughing during the early phase of healing, tissue separation may occur. It is realized that tissues can give way before suture material, but during these first few days the margin of safety is greater with non-absorbable sutures.

## OPERATIVE REPAIR OF HERNIA IN GENERAL

Our approach to this subject should be with an open mind since it is frequently not possible to be certain of the exact diagnosis until after the inguinal canal has been explored. It is not uncommon to find a combination of weaknesses in spite of the fact that the hernia which is demonstrated at operation may fall into one or the other of the broad classifications of direct or indirect hernia. It is usual with a large indirect hernia to find a greatly enlarged internal ring and weakness of the floor although the sac takes its origin above the deep epigastric vessels.

In children and in young adults in whom, as a rule, a firm floor exists, special care to dissect the sac high is all that is required, with the exception that the internal ring should be satisfactorily closed to discourage recurrence at this point of origin.

The status of the floor of the inguinal canal can best be evaluated by inserting a finger into the peritoneal cavity through the open sac. If there is obvious redundancy of the peritoneum and transversalis fascia, further attention should be given to this area.

The use of transplanted tissues are rarely necessary or desirable in effecting a repair and such unorthodox materials as skin,

wire mesh, etc., have little to recommend them.

If there is an absence of satisfactory tissues, strips of fascia lata are the best substitute for normal fascial layers. Splitting strips of the external oblique aponeurosis to anchor the internal oblique muscle to Poupart's ligament is a method which, fortunately, is declining in popularity. In addition to being extremely traumatic it diminishes the usefulness of a fascial layer that is of real value in strengthening the floor when repairing a direct hernial defect. As a method in indirect hernia one would have some difficulty in advancing a single logical excuse for its employment.

*Steps in Operative Procedure.* Any incision which gives adequate exposure to the inguinal canal may be employed. Short and transverse incisions are, as a rule, unsatisfactory except in young subjects in whom only resection of the sac is contemplated.

The aponeurosis of the external oblique should not be incised until after the fascia has been cleaned of all fat and the external ring clearly identified after which it is made lateral to its mid-point. This allows the medial leaf to be brought to Poupart's ligament without tension in case it becomes necessary to carry out this maneuver. The medial and lateral leaves are elevated to expose the "conjoined tendon" on the one hand, and the shelving edge of Poupart's ligament down to the pubic spine on the other.

In determining the existing defect the cord is gently mobilized and all connective tissue attachments are divided. Incision is made in the cremasteric fascia, and the structures of the cord are dissected to determine the presence or absence of a hernial sac. If none is found associated with the cord, the probable diagnosis of direct inguinal hernia can be made. In the majority of instances it is visible, protruding through a defect or a thinned-out transversalis fascia.

If an *indirect sac* is found, it is dissected from the surrounding structures and freed

high up to the internal ring. The presence of an indirect sac does not rule out weakness of the floor especially in older subjects. A finger is inserted into the peritoneal cavity through the sac and the floor of the inguinal canal is palpated. If definite redundancy exists, the subsequent procedures will vary with this finding. If no weakness is demonstrated, the remaining steps consist of high ligation and removal of the sac, after which the internal ring is closed with interrupted No. 30 cotton sutures to a point which allows an adequate opening for the exit of the cord. In closing the transversalis fascia at this point the final stitch includes the cremasteric fascia, being careful to avoid injury to the vessels and vas. Closure of the inferior angle of the internal ring is thus effected. Medial and lateral sutures through these same structures complete the closure of the opening. (Figs. 1 and 2.)

The external oblique aponeurosis is now closed with interrupted No. 30 cotton without transplanting the cord. If there is some question about the status of the floor, there is no real objection to suturing the medial leaf of the aponeurosis to the shelving edge of Poupart's and imbricating the lateral edge. However, this is usually unnecessary.

If obvious redundancy of the floor is noted, the transversalis fascia should be incised from the dilated ring down to the pubic region. (Fig. 3.) Invariably a large "direct sac" is encountered which is readily mobilized from surrounding structures, including the bladder. From this point the operative steps coincide with those described under "direct inguinal hernia."

If no sac has been demonstrated at the internal ring, the internal oblique muscle in the upper part of the incision is retracted upward and medially and the peritoneal reflection is demonstrated. This is picked up with two hemostats and opened. (Fig. 4.) A finger is inserted into the peritoneal cavity and the floor of the inguinal canal tensed upward. An incision is made

through the transversalis fascia and carried from the internal ring to the pubis, giving wide exposure to the direct sac. (Fig. 5.) The deep epigastric vessels are exposed and are elevated gently and held upward with a small piece of rubber tissue. A Kelly

will be found lying on the medial and inferior portion of the sac and actually forms a part of the hernia itself. The bladder is readily separated from the sac and only by so doing can this first important step, the removal of all redundant peritoneum,

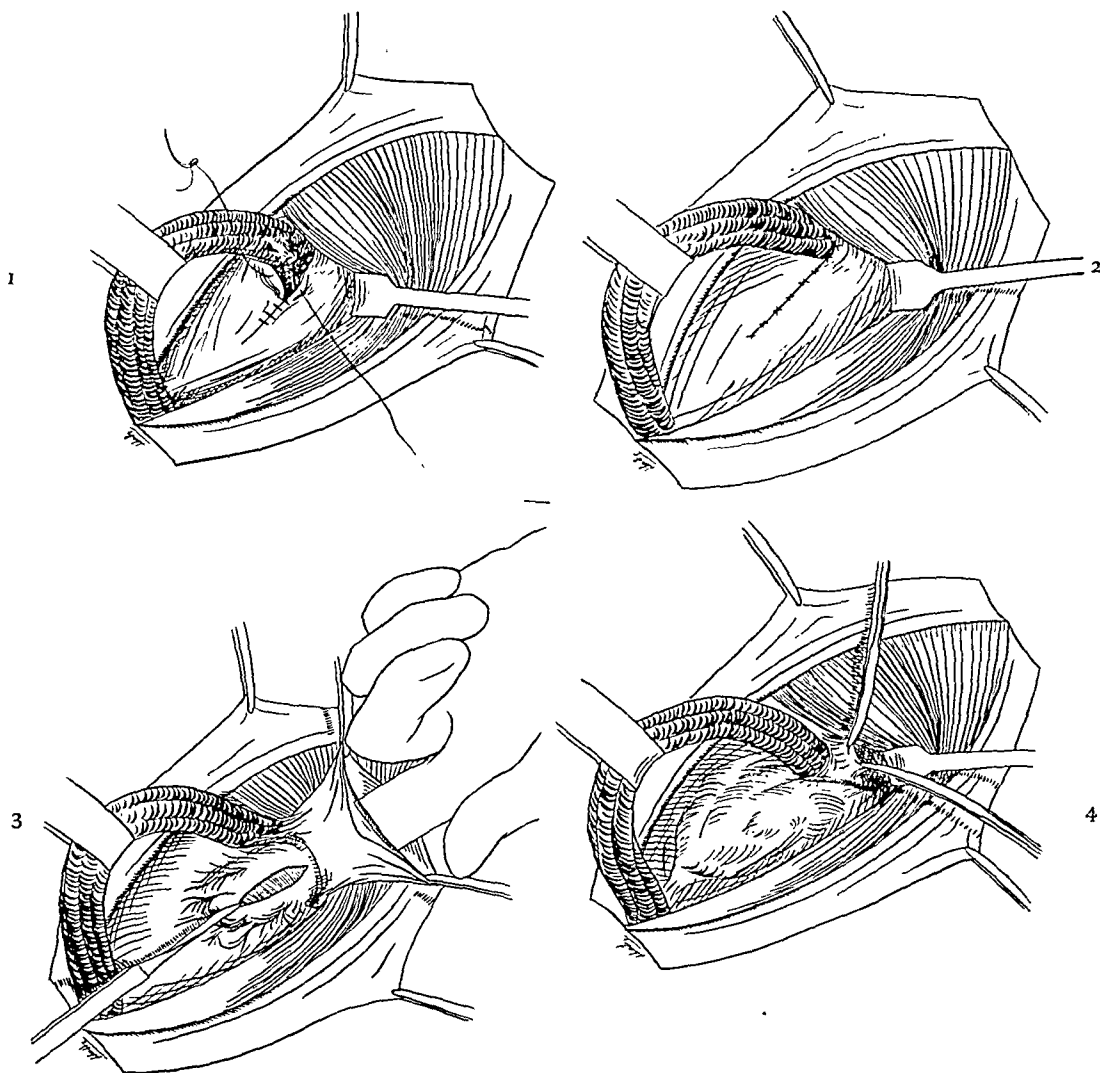


FIG. 1. Closure of the internal ring by suturing the transversalis to the cremasteric fascia. Sutures are placed at the inferior, medial and lateral aspects of the ring.

FIG. 2. The closure of the internal ring has been completed.

FIG. 3. In addition to an indirect sac, redundancy of the transversalis fascia indicates weakness of the floor which must be investigated.

FIG. 4. The peritoneum is picked up above the deep epigastric vessels.

clamp is passed beneath the vessels and the open peritoneum drawn down beneath them. (Fig. 6.) The direct sac now bulges high into the wound and the transversalis fascia is freed away by sharp and blunt dissection. If proper mobilization is carried out (Fig. 7), the bladder in every instance

be satisfactorily accomplished. A few small blood vessels are usually encountered which should be carefully tied off. The peritoneum is now incised from the original opening down to the bladder reflection, the excess excised and the remainder closed with a running suture of No. 00 chromic catgut.

A considerable amount of redundant transversalis fascia remains which should be approximated snugly with interrupted No. 30 cotton from its inferior angle up to

instances the fascia can be overlapped to form a double layer. (Fig. 8.)

*Comment.* The not infrequent practice of omitting resection of the sac in direct

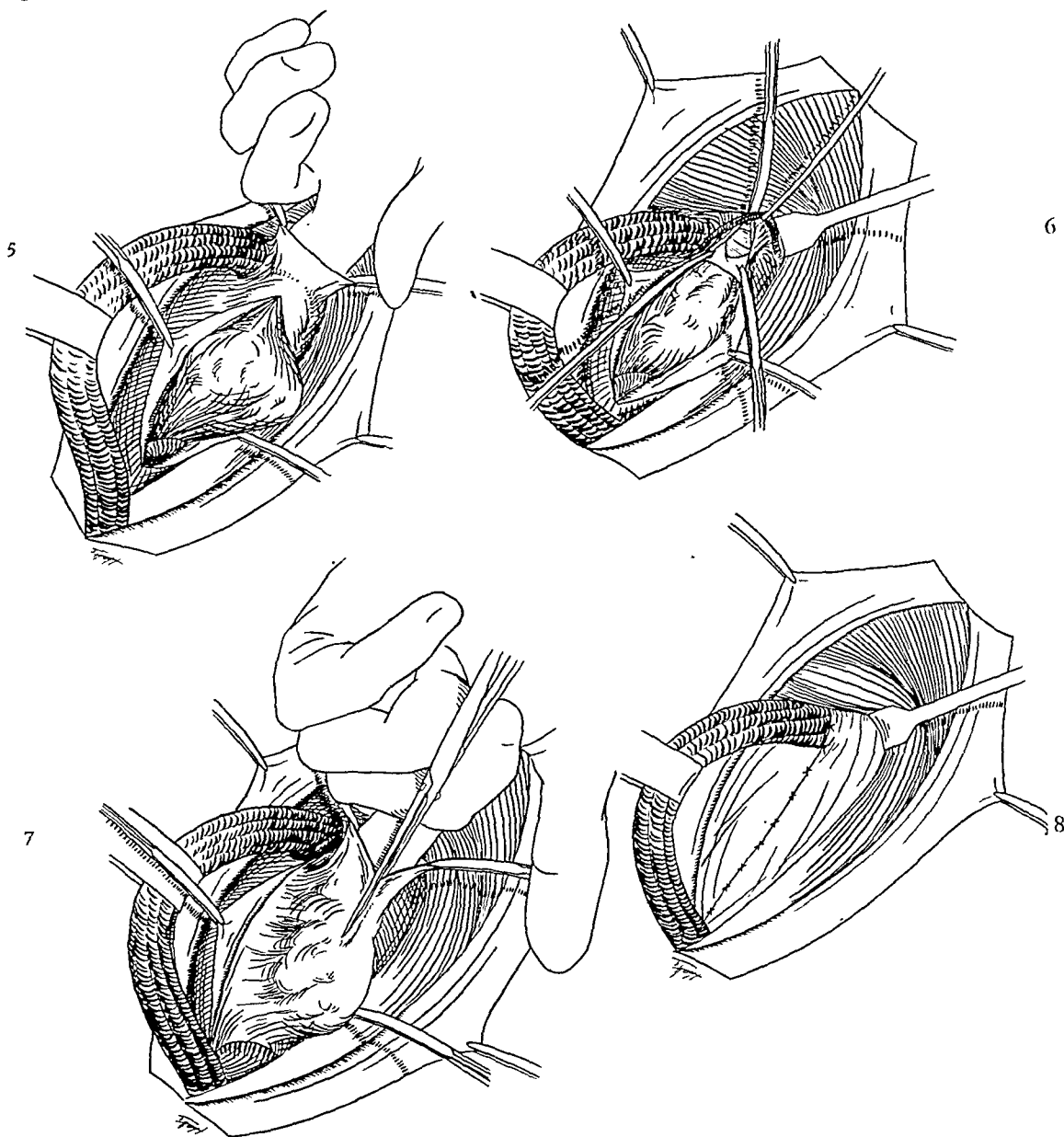


FIG. 5. With the finger in the peritoneal cavity, an incision is made through the transversalis fascia from the region of the deep epigastric vessels to the pubis. Note redundant sac and the attachment of the bladder to its inferior and medial surfaces.

FIG. 6. The opening in the peritoneum is drawn down beneath the deep epigastric vessels.

FIG. 7. After complete mobilization of the sac has been accomplished, it is widely opened to allow for excision of the excess.

FIG. 8. The transversalis has been snugly closed. Note closure of the internal ring.

the internal ring where the final suture should include the cremasteric fascia. Closure of the ring is accomplished in the same manner as in indirect hernia. In some

inguinal hernia is to be condemned. Unless some step similar to that which has been described is carried out, it is impossible to demonstrate the extent of the existing

hernia. Plication of the transversalis fascia without resecting the sac is a poor makeshift for a more adequate procedure and invites recurrence. The weakness has been covered but not repaired.

Opening the peritoneum above the deep

fascia, or both. It goes without saying that the careful execution of these two steps are of prime importance. It has been our policy also to seal the opening with interrupted sutures through the cremasteric and transversalis fascia, thus eliminating the

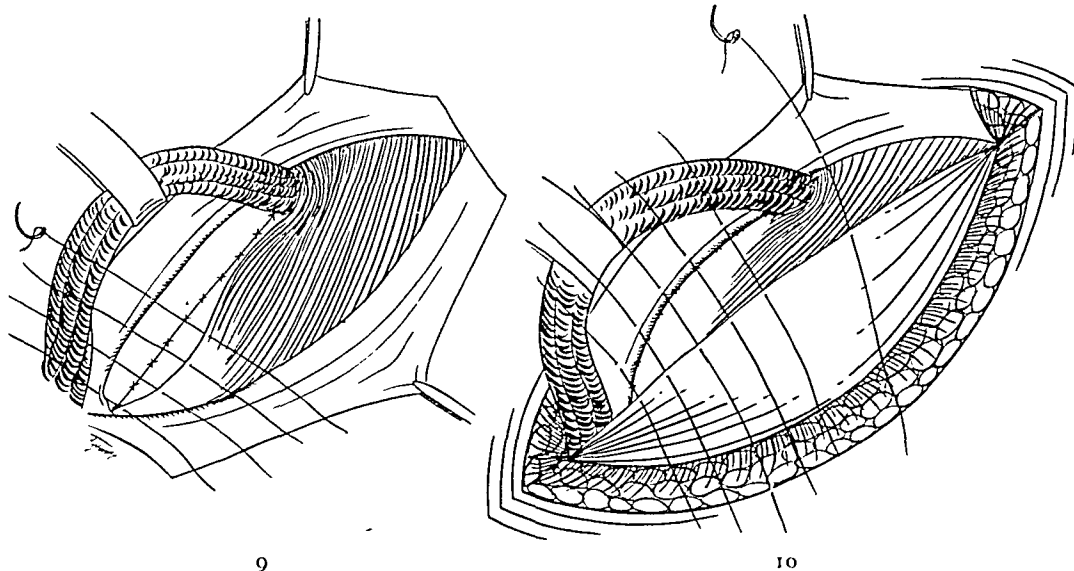


FIG. 9. The "conjoined tendon" is sutured to the shelving edge of Poupart's ligament.

FIG. 10. The external oblique aponeurosis is sutured to Poupart's ligament above the preceding suture line.

epigastric vessels and developing the sac after making a long incision in the transversalis fascia have proved useful in our hands. This has been especially true in obese subjects in whom a heavy layer of proportionate fat exists. In these cases especially the definition between this layer and the bladder is frequently indistinct. With one finger in the peritoneal cavity and using gauze dissection, the bladder is readily peeled off under direct vision, thus avoiding all danger of injury to this structure and allowing for rapid and wide mobilization of the sac.

Two common sites for recurrence are at the internal ring and the lower part of the floor. The latter in many instances represents inadequate removal of or an overlooked sac in this region, even though an indirect sac may have received proper attention.

At the internal ring recurrence may represent incomplete removal of the sac or inadequate closure of the transversalis

potential opening which must remain if this step is omitted. Entire dependence upon the fashioning of a proper-sized opening is thus obviated. We are constantly plagued by the knowledge that too small an opening will cause constriction of the cord and that too large a one will invite recurrence.

The other supporting layers through which the cord makes its exit may in similar fashion be sutured to the cremasteric fascia. If these steps are carefully carried out, recurrence at the internal ring should be a rare occurrence.

*Rebuilding the Floor of the Inguinal Canal.* Many opinions have been expressed about the inadvisability of suturing the "conjoined tendon" and internal oblique muscle to the shelving edge of Poupart's ligament. The principles of these arguments are sound, especially the reference to suture of dissimilar tissues and changing the normal course of muscle fibers. It is at once obvious that it has no place in the repair of an uncomplicated

indirect inguinal hernia; but when we are undertaking to rebuild and strengthen the floor, as is the case in direct hernia, it should usually be included. If the space between them is wide and the "conjoined tendon" is muscular throughout most of its course, this step probably contributes little to the repair. On the other hand, when a firm ligamentous structure does exist, especially at the lower third and when the structures in question can be approximated without tension, a strong support to the floor is created. It is usually possible to place at least three sutures of No. 16 cotton in this lower angle without distortion of tissues and without tension, the lowermost suture approximating the "conjoined tendon" to the periosteum of the pubic spine. Additional sutures may be used as long as the aforementioned factors are kept in mind.

The medial leaf of the aponeurosis of the external oblique is now sutured to Poupart's ligament with #30 cotton. (Fig. 9.) If the previous step has been omitted, this structure is brought to the shelving edge; if not, to just above the preceding suture line. The free edge of the aponeurosis is then imbricated over this line of sutures. (Fig. 10.) At the internal ring this structure is split at right angles to surround the cord. The superficial fascia and the skin are closed with interrupted No. 60 cotton. (Fig. 11.)

*Comment.* The use of this aponeurotic layer is, as a rule, the most useful tissue available for reinforcing the floor. As has been stated, the initial incision in this structure should be made carefully so that approximation is snug but without tension. This double layer of fascia is more dependable than the more variable "conjoined tendon" which may be muscular throughout most of its course. In those instances in which the external oblique aponeurosis is attenuated and has little potential support, a flap of the anterior rectus sheath may be turned down and sutured to the shelving edge of Poupart's ligament as an additional reinforcement.

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If the latter structure has been weakened by previous operations, Cooper's ligament should be utilized. Its routine use does not seem justified since it involves a technic that is more difficult for the average surgeon to execute.

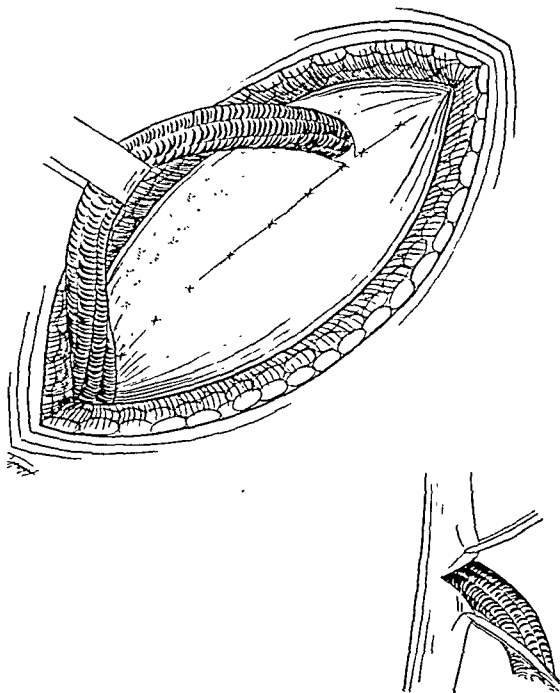


FIG. 11. The free edge of the aponeurosis is imbricated over the preceding suture layer and split at right angles at the internal ring to surround the cord (insert).

#### SUMMARY

The treatment of inguinal hernia is discussed with emphasis upon the careful execution of each operative step and avoiding the choice of a method until after the nature and extent of the weakness has been determined.

Stress is placed upon the wide resection of the peritoneal sac, firm closure of the transversalis fascia, including the internal ring, and in direct hernia the creation of a solid floor with the available normal tissues.

The sealing of the internal ring by suture of the cremasteric to the transversalis fascia, although only a minor contribution to the operation, has not to our knowledge been previously suggested.

# A SURVEY OF BRAIN TUMORS FOR THE GENERAL PRACTITIONER OF SURGERY\*

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TUMORS of the brain have not been commonly considered as part of the general cancer problem. Few symposia on cancer include the nervous system in the discussion. A tradition has developed, clinically, pathologically and in the field of oncology itself wherein new growths affecting the nervous system are thought of as things apart. There is some basis in fact for this tradition; on the other hand, interrelationships do exist in all these fields which merit attention. This discussion will concern itself with the general incidence of lesions of the nervous system, the more common signs suggesting their presence, available modes of establishing the diagnosis, a brief survey of the types of tumor affecting the brain, their prognosis and something of the trends to improve diagnosis and treatment.

There is good reason for the general practitioner of surgery to anticipate encountering a tumor of the brain. These growths constitute something over 2 per cent of all cancers and that is the general proportionate figure to bear in mind. The brain is reported to be among the three organs most commonly affected by tumor in females up to age sixteen and in males up to age thirty-nine.

Of the surgical specialists the ophthalmologist and otologist most often encounter the primary or secondary effects of intracranial neoplasms. These growths also may present signs of gastrointestinal disease. The thyroid surgeon, the gynecologist or the urologist may be the first to see the patient with tumor of the pituitary or third ventricle or the hypothalamus. All surgeons must consider the possible

cerebral metastasis of any cancer but this particularly applies to the thoracic surgeon and to him who removes many cancers of the breast. The list is incomplete that forgets the man who fulgurates "a little mole"; 50 per cent of malignant melanomas metastasize to the brain.

The term "brain tumor" has come to include not only the neoplasms of the cerebrum and cerebellum but all of those tumors of adjacent cranial or intracranial structures which may implicate the brain. Certain authors have said that only the intrinsic tumors of the brain, the gliomas, should be called cancers of the brain. Cancer, however, is defined as a "malignant growth of tissue" and malignant as "tending or threatening to produce death." We believe, therefore, that all new growths involving the brain, primarily or secondarily, are justifiably called cancers in the broad sense of the word. They merit consideration as part of the cancer problem.

With the gliomas, then, we discuss new growths arising from the meninges, the cranial nerves and the intracranial glands: cysts, tumors of blood vessels, certain tumors of the skull and metastatic lesions from primary growths elsewhere in the body. Because of the multitude of functions of the brain and of the intracranial glands, these tumors may elicit a wide variety of symptoms.

## CLINICAL MANIFESTATIONS

Clinically, there are some general basic neurologic signs whereby the presence of brain tumor may be recognized or suspected. Fundamentally, a brain tumor must be thought of as a single progressive

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Read at the Symposium on Cancer at the Clinical Congress of the American College of Surgeons, October, 1948.

lesion. It may irritate the brain initiating a convulsion, the initial manifestation of which will be on the side of the body opposite to the hemisphere involved. It may compress the brain or cranial nerves, gradually producing a progressive contralateral focal loss of function. A few tumors, by virtue of their anatomic position, may block the channels of the cerebrospinal fluid early and so increase intracranial pressure; usually, however, increased intracranial pressure is a late manifestation of intracranial growth.

To pursue these clinical manifestations in more detail, the unexplained appearance of convulsions after the age of twenty-one constitutes one of the cardinal signs suggesting the presence of tumor affecting the cerebrum and the clinical study of such a patient is incomplete until all reasonable available modes of investigation to eliminate the possibility of tumor have been carried out. Even then the patient with "negative" results must be followed periodically to be sure a small lesion has not escaped detection.

In this connection it must be remembered that motor phenomena constitute but one aspect of the convulsive state. Irritation of other cerebral centers may produce organic hallucinations. Irritation in the postcentral region may result in a sensation of numbness, tingling or pins and needles or a sensation of electricity. Stimulation by tumor of the occipital lobe may produce a sensation of lights or formed objects, usually in motion. The temporo-parietal region may respond with auditory hallucinations, often music or voices. A lesion in the tip of the temporal lobe may result in a sensation of taste or of odors. Autonomic discharge may indicate a lesion affecting the deep lying centers near the third ventricle or areas connected with this region. Any of these hallucinations may be isolated experiences or may constitute the aura of a motor attack.

Focal paralysis of cerebral activity may appear as an initial sign or may follow evidence of irritation. Progressive motor im-

pairment, particularly that which involves successively the two extremities on one side of the body, should always raise the question of brain tumor in the precentral frontal cortex or its connections. The movement of the face is impaired but slightly if at all. Usually there is spasticity with increased deep reflexes and the appearance of pathologic signs such as the positive Babinski. Paralyzing involvement of the postcentral or sensory region will produce loss of appreciation of texture, form, weight and two-point discrimination. Paralysis of the optic pathway or cortical center produces a homonymous defect in part or all of the contralateral visual field. Often this defect will have been unnoticed by the patient. A homonymous field defect is one of the most commonly overlooked signs of tumor of the brain.

Hypofunction of the pituitary gland may result from lesions near the sella turcica. They may involve the structures near the third ventricle producing somnolence, metabolic disturbance, such as diabetes insipidus and obesity, and sexual dystrophy.

A frankly psychopathic state is not a common diagnostic sign of brain tumor. Invasion of the corpus callosum or of the deeper portions of the temporal lobe may, however, result in a psychosis which may be the presenting evidence of disease. Change in personality or temperament is reported more often and is seen with any extensive intracranial disease.

Speech may be affected by tumor involving the dominant cerebral hemisphere of the brain, the left hemisphere in right handed individuals. Transitory aphasia may be associated with convulsive attacks firing from the dominant side. Loss of speech progressing to complete inability to use or understand language can be a manifestation of tumor in the same hemisphere. Either of these may have considerable value in the lateralization of a lesion.

Below the tentorium tumor of a cerebellar hemisphere usually produces ipsilateral signs such as unsteadiness of gait, relaxation of muscular tone and altered



reflexes, difficulty in performing rapidly alternated movement and a tendency to past point toward that side. The head may be tilted toward the side of the lesion and lateral nystagmus will be coarse and slow in that direction. A tumor near the midline may produce only body ataxia or unsteadiness of the trunk. Increase of intracranial pressure often occurs early in cerebellar tumor. If there is pressure in the aqueduct at the level of the tentorium, there may be interference with upward movement of the eyes. Pressure on the pons or medulla will produce the "cerebellar fit," actually a decerebrate state due to mass involvement of the paths of the brain stem.

Tumor in the pons and medulla progressively involves the cranial nerve nuclei and spinal tracts of this area; the signs will be those of successive loss of cranial nerve and spinal tract function. These growths rarely block the cerebrospinal fluid pathways, hence intracranial hypertension usually does not complicate the picture.

The signs of cerebellar tumor in childhood deserve special attention. Because the growths are usually in the fourth ventricle, cerebrospinal fluid circulation is interfered with at a relatively early stage. General and focal signs appear in rapid sequence. The child who becomes increasingly clumsy in leg, arm or body movements and who has bouts of nausea and vomiting may well have a medulloblastoma and deserves further study. The appearance of papilledema and of the "cracked pot" note usually should remove any possible hopeful doubt. Optimistic inactivity is then itself "malignant."

Paralysis of cranial nerves may result from pressure from within or without the nerve involved. Tumor in the region of the sella turcica and olfactory groove may press on the optic chiasm producing visual loss first in the temporal fields but potentially progressing to complete blindness. Many of these tumors can be well controlled if seen early. Sellar lesions also may inhibit function of the olfactory nerve, the

third, fourth and sixth nerves (the nerves of ocular motion) and the trigeminal.

Loss of hearing of the type called nerve deafness may be due to causes other than tumor and these generally receive first consideration. As a result tumor of the eighth nerve, which constitutes one-tenth of all brain tumors, is seldom diagnosed before other cranial nerves from the trigeminal to the hypoglossal and the brain stem itself have become involved in its capsule adding tremendously to the hazard the patient must take. Early diagnosis may well be followed by complete cure.

The third general sign of brain tumor is increased intracranial pressure, which may result from the great size of a tumor or from its interference with the normal flow of cerebrospinal fluid or both. Occasionally interference with venous drainage of the brain may appear to be a factor. Usually intracranial hypertension develops late in the disease. Headache is the most frequent complaint of these patients. Actually headache is the most common single initial symptom of brain tumor but this fact is not to be applied uncritically. It must be obvious that a symptom as common as headache in the population at large, rarely is indicative of brain tumor. The headache of brain tumor is of increasing frequency and severity, is often nocturnal and is rapidly joined by other signs of an expanding intracranial lesion such as nausea, vomiting and papilledema (choked disc). In children a peculiar "cracked pot" note may be elicited on tapping the skull. In late stages there will be a slow, bounding pulse; drowsiness will be followed by stupor and coma. By this time even heroic measures can seldom save the victim no matter what the underlying tumor type may be.

#### DIAGNOSTIC PROCEDURES

If a tumor of the brain is suspected, the Wassermann reaction first must be known; syphilis, which may mimic brain tumor, too often is forgotten. Probably the next special study to consider is an x-ray of the skull including a basilar projection. Some

tumors of the brain contain radiopaque salts and occasionally these show characteristic morphology on the x-ray film. The pineal gland may be calcified, the chance increasing with the age of the patient. A significant shift of the position of the pineal may be highly important. The sella may be enlarged, distorted or eroded. There may be areas of thickening or of erosion of the skull; the basal projection may be invaluable here.

Occasionally an electroencephalogram will be indicated although this tool is usually more valuable in other fields of neurology.

If the intracranial pressure is normal, the cerebrospinal fluid may be replaced with oxygen or air (pneumoencephalography) and x-ray films taken which will show the position and possible alterations of size and shape of the ventricular and subarachnoid spaces. If the intracranial pressure is elevated, the fluid-gas exchange will be safe only when carried out directly through ventricular puncture (ventriculography). Ventriculography should be followed immediately by craniotomy if a tumor is demonstrated. The patient's hazard is significantly increased if there is delay in treatment following the demonstration of tumor by this test.

Cerebral angiograms may be of value, particularly when cerebral tumor is suspected. Lesions have been demonstrated by this method when all other methods of precise anatomic localization have failed.

None of these refinements of study is infallible. Occasionally exploratory craniotomy may be defended; usually it cannot be if none of these tests demonstrates a lesion. Generally it is wisest to follow the clinical developments, being constantly alert and willing to repeat tests should occasion arise. Remember, the hypochondriac and the doctor of medicine complain too early and are often finally diagnosed too late.

#### TYPES OF BRAIN TUMORS

About 50 per cent of brain tumors are intrinsic growths arising from cells related

to the embryonic or adult glial series and are designated gliomas. Certain generalizations regarding this group of tumors are in order. They occur at any period of life from infancy to old age, more often in males than females. In adults gliomas are most often found in the cerebrum, whereas those in the cerebellum and brain stem have a greater incidence in childhood. They are always invasive, never being encapsulated in the true sense of the word. They may spread to the meningeal surface and become attached to the dura mater but they do not advance beyond it. They seed into the subarachnoid space and ventricles but almost never metastasize outside of the craniospinal cavity.

For purposes of more accurate clinical appraisal gliomas were classified into various subtypes by Baily and Cushing in 1926. The nomenclature used here stems from their original classification. Because it occurs in all subdivisions of the central nervous system, astrocytoma is the most commonly encountered of the gliomas, accounting for over one-fourth of them. Except for fibrous astrocytoma of the cerebellar vermis it is a glioma of adult life occurring in the cerebrum and cerebellar hemispheres most often during the age period of thirty to sixty. There are three subtypes. Fibrous astrocytoma, a firm, sometimes cystic tumor, grows the most slowly and has the best prognosis; protoplasmic astrocytoma, the least common, is the most insidiously invasive and the most difficult to treat surgically; gemistocytic astrocytoma is the most rapid in growth, the average survival being twelve to eighteen months.

Glioblastoma multiforme, accounting for another 25 per cent, is the most malignant of the gliomas and is the one most commonly found in the adult cerebrum. A wild neoplastic process which involves blood vessels as well as neuroectodermal elements, its onset may be so precipitous as to suggest a cerebrovascular accident and its total clinical course sometimes may be measured in months. It particularly strikes

down males in the prime of life. This tumor ranks with gastric carcinoma in seriousness of outlook.

Medulloblastoma is the next most common glioma and is the one most often encountered in infancy and childhood. Some have said that it never occurs other than before the age of sixteen believing that a similar tumor of adult life that has certain features not seen in medulloblastoma of childhood should be designated cerebellar sarcoma.

Medulloblastoma rapidly blocks the flow of cerebrospinal fluid and clinically produces the syndrome of increasing awkwardness and cyclic bouts of vomiting followed by loss of vision and stupor. The cranial sutures will be separated allowing a "cracked pot" note on percussion of the skull; there will be papilledema. After the intracranial pressure has been reduced, the tumor at first will respond well to carefully planned x-ray therapy but loses this susceptibility with successive treatments. Secondary tumors commonly occur in the spinal subarachnoid space, the lateral ventricles and over the convexity of the brain. Survival for as long as five years is uncommon, the average being twelve to eighteen months.

We should also mention ependymomas related to the cells lining the ventricles of the brain and central canal of the cord; polar spongioblastomas related to the primitive supporting cells of the brain and the embryonic forebears of the adult neuroglia; and oligodendrogliomas related to that adult glial cell, the oligodendroglia. All of these tumors grow slowly; survivals with ependymoma and oligodendroglioma for as long as ten or fifteen years are not rare. Because of its unfavorable common location in vital areas the polar spongioblastoma does not carry as encouraging an outlook. The remaining gliomas are rare or fall into that group of varying size in any series, the unclassified gliomas.

Tumors of the meninges are next in frequency, constituting about one-eighth of the brain tumors. These growths occur in women more often than in men. Most are

leptomeningeal in origin and tend to arise near the venous sinuses of the cranium. They are encapsulated tumors but lobulated projections into the cranial cavity may adhere to or pinch off cerebral tissue, thus damaging the brain. Meningiomas may invade the skull and any bony lump on the skull of an adult may be the result of an adjacent meningioma. Although the vascularity of these tumors is usually troublesome, a large percentage of them lie in an area where they can be completely removed and the prognosis is accordingly good. Recurrence or multiple tumors, however, do occur. Reoperation to handle these is usually recommended. Subgroupings of meningiomas exist but are beyond the scope of this presentation.

Tumors of the cranial nerves occur most commonly in the posterior fossa of adults, usually arising there from the eighth or auditory nerve and occasionally from the others, particularly the glossopharyngeal. The most common type, perineurial fibroblastoma, arising from the nerve sheath, accounts for about one-tenth of all brain tumors. Neurofibroma, as in von Recklinghausen's disease, is relatively less common. In adult life chromophobic and eosinophilic adenomas of the pituitary may press upon the optic nerves and the hypothalamus as well as upon the normal gland and, hence, may become clinically important to the neurosurgeon. In addition eosinophilic adenoma will produce the syndrome of acromegaly. In childhood, cystic tumors arising from cell rests of Rathke's pouch may produce similar regional signs. The hypothalamic effect is usually more impressive in this group.

Tumors of the pineal also excite interest chiefly as they may press upon neighboring essential structures. Epidermoid and dermoid cysts arising from epithelial cell rests may occur whenever there has been embryonic infolding of ectoderm and in their growth may adhere to and press upon vital structures, often in the midline.

Tumors of the skull, notably chondromas of the base, osteomas and myelomas, may

implicate the adjacent brain or cranial nerves in the course of their development.

True neoplasms of blood vessels, the hemangioblastomas may act as intrinsic or extrinsic growths, often cystic. The cavernous angiomas are considered to be congenital vascular anomalies manifesting themselves by progressive engorgement or rupture of blood vessels producing spontaneous cerebral hemorrhage.

Any primary malignant growth in the orbit, neck or nasopharynx may invade the cranial cavity by direct extension. Other cancers may metastasize to the brain; a particular predilection exists with cancers of the lung, the breast and the retroperitoneal space and the stomach. It is said that 50 per cent of malignant melanomas metastasize to the brain. The site of the daughter growth roughly parallels the blood supply to the area.

#### PROGNOSIS

Operative mortality now compares favorably with that of any other major surgical procedure. The over-all postoperative prognosis depends entirely on the nature and the location of the lesion. Rapidly growing neoplasms like glioblastoma multiforme and medulloblastoma seldom permit survival for as long as five years. The course is usually run in twelve to eighteen months in spite of radical excision and x-ray therapy. The outlook with the other gliomas is more hopeful, especially for those in the cerebral poles and the cerebellar hemispheres. Survivals of from three to five years are often encountered and those over five years cannot be considered rare. Statistics for these invasive tumors are in line with those for malignancy in the lung, stomach or any relatively vital organ.

The outlook for the encapsulated growths (meningiomas and perineurial fibroblastomas of cranial nerves) is much brighter and is dependent on size and location. If seen reasonably early, there is a good chance that complete removal may be possible. Size, vascular connections and the related adhesion of the tumor to the brain stem

are the limiting factors in the successful treatment of cranial nerve tumors. The need for early diagnosis here cannot be over-emphasized.

Patients with pituitary tumors often can be carried for many years by the judicious use of x-ray therapy and surgery. Frequently obtained visual fields allow early recognition of regrowth so that appropriate steps may be taken. Tragedy occurs, however, when the growth involves the hypothalamus or has produced irretrievable damage of the optic nerves.

Cysts in their early stages may be excised. Too often they have become attached to vital structures before their presence is known. Even then palliative methods may carry the patient along for a considerable number of years.

Single tumors of the convexity of the skull usually may be excised, the outlook then depending upon the type of lesion found. Tumors of the base are less hopeful but palliative treatment is often possible. Many basal growths are metastatic or local invaders.

The cavernous angiomas rupture, producing a massive brain hemorrhage. Until recent years a tradition existed that these masses could not be removed successfully and the victims carried on with death within, rather than over their heads, awaiting their fate. Improved operative technics now permit the removal of many of these anomalies. The morbidity is high although often not much greater than that present before excision. The danger of death from overwhelming hemorrhage is removed with the angioma.

The outlook in metastatic tumor of the brain is related to that of the parent growth. Single metastases from slowly growing cancers probably merit removal if the daughter tumor seems to be in an accessible area. Each problem must be weighed on the over-all merits of the case.

A word concerning preoperative impression as to tumor type is necessary. In the past a tendency to make a pathologic diagnosis on clinical grounds has appeared and

on this basis alone operation has been withheld when the suspected growth was believed to carry a poor prognosis. There is no certain way of diagnosing a tumor of the brain, even metastatic, without gross and microscopic study. The number of tumors thought preoperatively to be invasive but later proved to be removable is great. Too often the proof has been at the autopsy table for in the brain any growth may kill if left untreated.

The prospects for improvement in diagnostic and therapeutic methods are the same, of course, as in other fields of the general cancer problem. It is believed that with experience the tools of angiography and electroencephalography will become of greater service. The potentialities of pneumography have not been exhausted. Radioactive elements which emit beta and

gamma radiation are taken up by gliomas and give particular promise of value in localizing and delimiting them. Operative technics are improving. The use of fluorescent dyes to demonstrate at operation the reaches of such tumors as the glioma is promising. Our colleagues in roentgenology are constantly adding to their efficiency in the therapeutic use of x-radiation. Cytocidal elements are being developed and studied in laboratories of oncology and the possible application to tumors of the brain is ever in mind. Probably the most promising immediate source of hope to the patient with a brain tumor is the increasing alertness of the members of our profession to the possibilities of successful treatment if diagnosis is prompt. We seem to be seeing these patients with tumor earlier.



# THE TECHNIC OF OPERATIVE CHOLANGIOGRAPHY

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THE roentgenographic visualization of the extrahepatic biliary system following the introduction of contrast solutions was first described by Reich<sup>16</sup> in 1918. He injected a thin mixture of petrolatum and barium paste into an external biliary fistula and obtained an accurate roentgenographic pattern of the obstructed bile ducts.

Cotte<sup>3</sup> in 1929 suggested the advisability of contrast cholangiography at the operating table but dismissed the procedure as difficult and inconvenient. Mirizzi,<sup>13</sup> however, grasped the significance of this suggestion and in 1932 he made a masterful presentation of his methods and observations in "cholangiography during operation, based on a personal experience of 91 cases." Several authors<sup>2,5,6,9,10,17,18</sup> have made contributions to the technic and value of operative cholangiography. Its popularity and widespread acceptance are confirmed by 289 articles which have appeared in the literature on this subject.

Since 1934 we have employed visualizing cholangiograms in all operations on the extrahepatic biliary system. More than 1,700 studies have been made and from this experience much information has been obtained. Operative cholangiograms demonstrate congenital aberrations and anatomic displacements of the extrahepatic biliary system; determine patency of the ductal system; note number and position of offending calculi; designate functional status of the sphincter of Oddi;<sup>11</sup> outline fistulous communications;<sup>8</sup> visualize bile reflux into the pancreatic ducts; detect intrusions of neoplasms which impinge on the large bile ducts or originate in the

ampulla of Vater; and visualize dilatation, sacculation or diverticular enlargements of the bile ducts themselves. Such exact information permits the surgeon to select the operative procedures best suited to alleviate existing pathologic abnormalities.

## TECHNIC

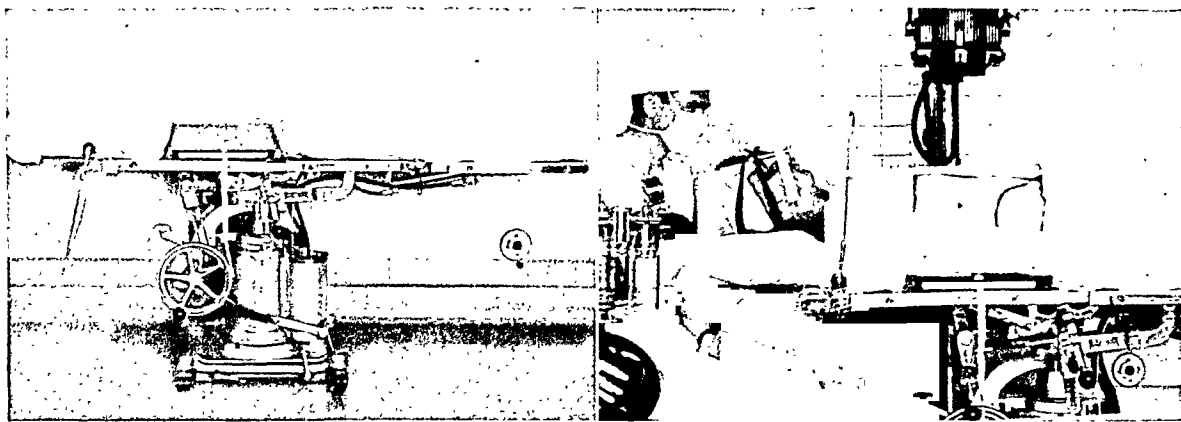
The technic of operative cholangiography is simple and does not complicate or prolong surgical procedures. There have been no infections, undesirable inflammatory reactions or constitutional complications associated with cholangiography. The simplicity of technic and the absence of untoward reactions eliminates any objections which either the surgeon or patient might advance.

*Contrast Solutions.* A suitable contrast solution for cholangiography should fulfill the following requirements: (1) It should be freely miscible with bile and the resulting solution should have such a fluidity that it will readily flow into the finest biliary radicals; (2) it must possess such a high degree of radiopacity that a minute amount of the solution is capable of producing a distinct radiographic pattern of the smaller bile ducts; (3) it should be non-irritating to all types of tissues and incapable of producing constitutional reactions when absorbed from the gastrointestinal tract; and (4) the solution must be sterile and stable.

During the past fourteen years we have had extensive experience with such radiopaque solutions as lipiodol,<sup>9</sup> lipoiodol, lipoiodine,<sup>9</sup> hippuran, rayopake, thorotrast,<sup>9</sup> skiodan, skiodan viscus and diodrast 35 and 70 per cent.

We believe that the halogenated oils are

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FIG. 1. Photograph showing how an ordinary operating table can be utilized for cholangiography. The central portion of the rubber padding is removed to accommodate the wooden tunnel which contains a Lysholm grid cassette and 10 by 12 inch film. Note the tape attached to tunnel so as to facilitate removal of the cassette.

FIG. 2. Photograph depicting the cholangiographic unit. The cassette is placed so as to include upper right and medial portions of the abdomen; the x-rays are centered over a point midway between the nipple and the crest of the ilium. By means of endotracheal intubation the anesthetist is able to control all respiratory motion.

inferior to the aqueous iodized solutions for cholangiographic visualizations.<sup>9</sup> The oils are not miscible with bile; therefore, they tend to "puddle" or stratify, making it difficult to determine whether the negative intraductal shadows are produced by stones, incarcerated air bubbles or by the stratification of bile. Iodized oils have such a high viscosity even when heated to the temperature of the body that they will not flow along the small intrahepatic radicals or traverse narrow tract of internal or external biliary fistula. Failure to fill these structures with the contrast media results in incomplete pattern of the biliary tract and reduces the diagnostic value of the cholangiogram. The high compact radiopacity of the halogenated oils may effectively obscure the shadow of small stones. This is particularly true if the bile ducts have a diameter greater than 50 mm.

Experimentation soon proved that most of the aforementioned objections could be eliminated by the use of aqueous halogenated solutions. Idio pyracet, known as diodrast, is an excellent cholangiographic agent. Diodrast is available in a 50 cc. ampule and the solution is both stable and sterile, hence, it is ready for immediate use. When injecting the gallbladder or the dilated bile ducts, we prefer to use 35 per

cent diodrast. However, if the ducts are of normal size, 70 per cent diodrast gives the better radiographic patterns.

*X-Ray Technic.* While the technic of cholangiography is simple, it does require coordinated team work between the radiologic and surgical departments if good films are to be obtained. Any operating table can be adapted for cholangiography by placing a wooden tunnel (Fig. 1) containing a 10 by 12 inch x-ray film directly beneath the patient so as to include the upper right and medial portions of the abdominal cavity. (Fig. 2.) Several attempts have been made to employ the urologic table for these studies but the mechanical arrangements of the supporting uprights is such that they interfere with the exploration of the abdomen. In order to improve the quality of the radiographs we are constructing a surgical table with a built-in Potter-Bucky diaphragm and utilizing equipment capable of a higher output than the standard portable units. While such conveniences are desirable, they are not a necessity.

When the skin incision has been made, protective towels and drapes are securely anchored to the margins of the wound by cotton or silk sutures. This obviates the use of towel clips which prevent the possi-

bility of having x-ray shadows of the instruments obscure important segments of the biliary tract, thus reducing the effectiveness of the cholangiograms.

After the operator has completed the palpatory examination, an adequate amount of diodrast is injected into either the gallbladder or bile ducts. All packs and instruments are removed from the wound so as to reduce distortions and the operative area is covered with a protective sheet. The portable x-ray unit is quickly placed in position, with the tube-film distance about 25 inches. (Fig. 2.) The exposure time which depends on the thickness of the patient has been predetermined by measurements. When the technician is ready to take the radiograph, the anesthetist hyperventilates the lungs and maintains a period of apnea at the height of the inspiratory phase. As all anesthetics are administered by endotracheal intubation, the apnea can be maintained for several seconds. This eliminates respiratory motion of the thoracic cage thereby reducing distortions. Inability to control respirations has caused us to abandon all forms of anesthesia which cannot be given by the endotracheal route. The technician immediately removes the film from the tunnel and develops it; within a period of five minutes she returns with the informative cholangiogram. It is imperative that the radiogram be taken immediately after the introduction of the diodrast; otherwise the solution might escape into the duodenum, in which event the biliary tract would not be visualized. Only experience and teamwork can reduce the time interval so that delays are obviated.

#### TYPES OF CHOLANGIOGRAMS

Selective cholangiography permits visualization of the gallbladder and all the bile ducts as one unit or definitive studies can be made of isolated segments of the extrahepatic biliary system.

*Scout Cholangiograms.* Scout cholangiograms provide a composite radiographic pattern of the gallbladder and the entire

ductal system and are particularly useful in cases of obstructive jaundice whether due to stones, strictures or ampullary tumors. As soon as the abdomen has been opened, careful visual and palpatory examinations of the liver, gallbladder, bile ducts, pancreas and stomach are made. A No. 20 gauge needle is then inserted into the lumen of the gallbladder and its liquid contents are aspirated and replaced with 40 to 50 cc. of diodrast. (Fig. 3A.) As soon as the gallbladder and bile ducts appear to be completely filled with the contrast solution, the needle is withdrawn and the small perforation in the gallbladder wall is crushed so as to prevent extravasation of the diodrast. The operative field is immediately covered with a sterile sheet so that the radiograph can be taken. The resulting cholangiogram provides a complete visual pattern of the gallbladder and the bile ducts, denoting patency, obstructions, calculi and anatomic abnormalities. If the larger bile ducts are patent and the contrast fluid passes into the duodenum, a cholecystectomy can be performed. (Fig. 3B.) Should the choledochus harbor stones, it becomes necessary to remove the offending calculi before proceeding with the cholecystectomy.

Scout cholangiograms will not visualize the common bile duct if the cystic duct is occluded by stones or strictures because the diodrast, which was injected into the gallbladder, cannot find entrance into the larger bile ducts. When confronted with this situation, a second cholangiogram is obtained by injecting 15 cc. of 70 per cent diodrast directly into the lumen of the choledochus. (Fig. 4A.) This provides a complete picture of the functional status of the bile ducts themselves. If no abnormalities are detected, the gallbladder can be safely removed. (Fig. 4B.)

We employ scout cholangiograms when uncertain of the diagnosis or if we desire to determine the extent of the pathologic process. When confronted by obstructive jaundice, it is useful to know whether the gallbladder should be preserved for short



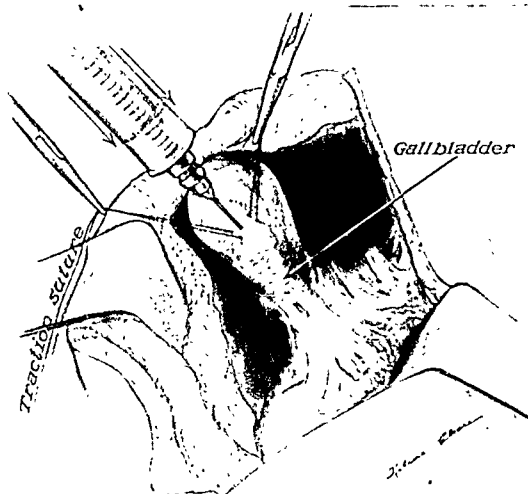


FIG. 3. A, drawing showing the technic of obtaining a scout cholangiogram. A No. 20 gauged needle is inserted into the gallbladder lumen and the bile is aspirated and replaced with 40 to 50 cc. of diodrast (70 per cent). If the cystic duct is unobstructed, the diodrast enters and fills the larger bile ducts.



FIG. 3. B, scout cholangiogram revealing normal extrahepatic biliary system. The gallbladder does not contain stones; the cystic duct is patent and all of the biliary radicals are normal in size and shape. No obstructions are visualized. Note that the choledochus occupies a medial position rather than its usual location along the right lateral margins of the vertebral column.

circuit operations. Such information can be readily obtained from these composite radiographs. No extirpative surgery is attempted until satisfactory cholangiograms have been obtained.

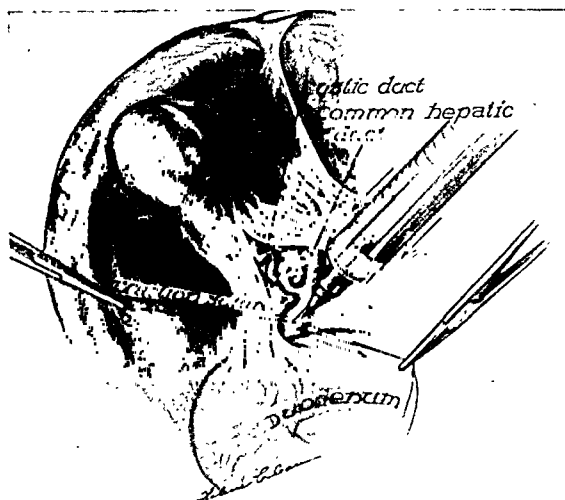


FIG. 4. A, method of visualizing the extrahepatic biliary system before removing the gallbladder. The hepatoduodenal ligament has been incised so as to expose the cystic duct and common duct. The aspirating needle is inserted into the lumen of the choledochus and the bile is aspirated. From 10 to 15 cc. of diodrast (70 per cent) is injected into the choledochal lumen and an immediate radiograph is taken.

**Choledochograms.** As a rule direct visual inspection and careful palpation will reveal the extent and nature of the cholecystopathy, hence, visualizing studies of the gallbladder may not be necessary. It is imperative, however, that the surgeon determine the functional condition of the larger bile ducts; this can be accurately accomplished by means of the choledochograms. The first step in this procedure is placing two silk sutures in the anterior wall of the common bile duct. Gentle traction on these sutures pulls the anterior wall of the choledochus away from its posterior wall, thus making it easier to inject contrast solution into the ductal lumen. (Fig. 5A.) Before this plan the exploring needle often passed through both the anterior and posterior walls of the common bile duct so that the diodrast was introduced into the retrocholedochal tissues. The extravasated diodrast not only blurred the outlines of the ductal system but occasionally produced a slight chemical irritation resulting in ductal spasms. Such complications are unnecessary and signify improper technic. If the resulting choledochogram demonstrates the bile ducts to



FIG. 4. B, note the enormous dilatation of the larger bile ducts and the calculus wedged in the ampulla of Vater so that the bile cannot enter the duodenum. The dilated common bile duct is pushed to the left margin of the lumbar vertebra and its upper portion occupies a transverse position. The gallbladder lies over the vertebra and the long tortuous cystic duct passes laterally then turns medially to unite with the common hepatic duct. The cholangiogram not only visualizes the anatomic aberrations of the biliary system but definitely localizes the offending obstructions.

be normal, further surgical explorations can thus be avoided. Should the radiographs reveal the presence of stones, the troublesome calculi can be removed. (Fig. 5B.) These choledochograms can be done after the gallbladder has been removed but we prefer to visualize the common duct before disturbing the gallbladder as it provides a wider latitude for corrective operations should unexpected conditions be encountered.

Operative choledochograms are particularly useful when exploring the biliary system of patients who have had previous cholecystectomies and who are still complaining of symptoms indicative of ductal obstructions. Frequently the periductal fibrosis and inflammatory reactions make it difficult to locate the common bile duct.

September, 1949



FIG. 5. A, method of exploring the common bile duct radiographically after the gallbladder has been removed. The two traction sutures which have been placed in the anterior wall of the common bile duct are used to pull the anterior wall away from the posterior wall. When the exploring needle is within the ductal lumen, as evidenced by the aspiration of bile, 10 to 15 cc. of diodrast is injected through the needle.

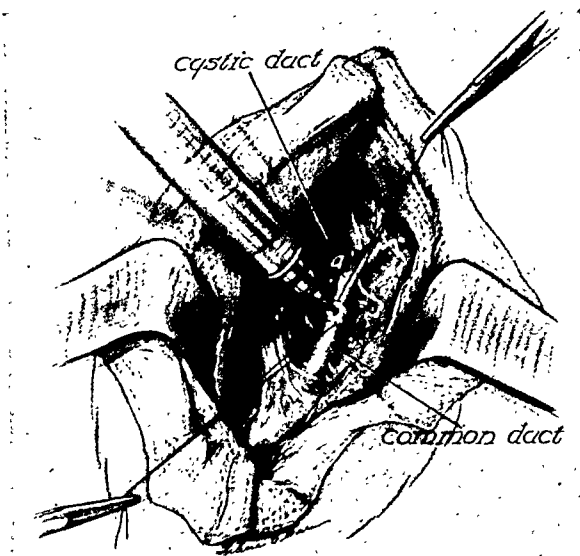


FIG. 5. B, this choledochogram vividly outlines the small calculus which is lodged in the ampulla of Vater. The dilated common duct signifies a long-standing obstruction. The stone does not completely occlude the ampullary orifice because the diodrast flows into the duodenum. This stone could not be located by palpitory examinations even after it was recognized by this choledochogram.

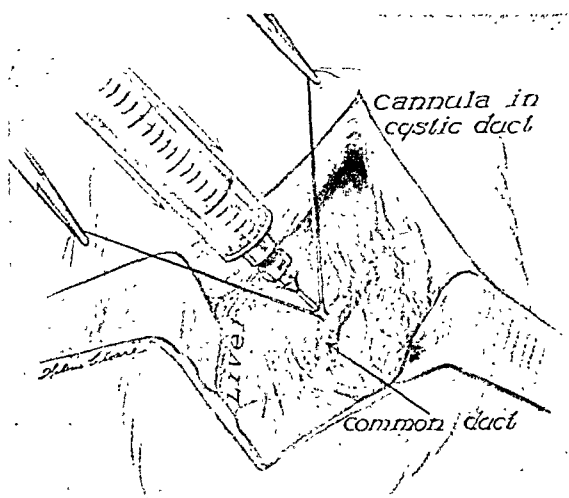


FIG. 6A



FIG. 6B

FIG. 6. A, method of utilizing the cystic duct for introduction of the contrast solution. The two traction sutures are placed in the lips of the severed cystic duct to expedite its cannulization. About 10 to 15 cc. of diodrast is injected into the ductal system. B, composite cholangiogram. Note the long redundant stump of the cystic duct which passes downward along the right lateral margin of the common hepatic duct before effecting its union. The choledochus occupies a normal position, it is not dilated, no "negative shadows" are seen and the diodrast passes rapidly into the duodenum; hence, no further exploration is warranted.

We prefer to visualize the choledochus and localize the obstructing lesions by employing cholangiography. After identifying the

right margin of the hepatoduodenal ligament, an exploring needle is gently introduced into these tissues at various points. When bile is aspirated, it is evident that the exploring needle is within the choledochal lumen; 10 to 15 cc. of 70 per cent diodrast is injected into the duct and a choledochogram is obtained. (Fig. 5A.) The operator has a visual pattern of the common bile duct denoting its anatomic position and depicting the exact location, nature and extent of the obstructive lesions. Such information permits a judicious selection of the reparative operation.

*Utilization of the Cystic Duct Stump.* Accurate cholangiograms can be obtained by injecting the diodrast directly into the stump of the severed cystic duct. Simple radiologic explorations of the common bile duct can be quickly performed by grasping the margins of the stump of the cystic duct with two Allis clamps, intubating its lumen with a small pliable metal cannula and introducing the requisite amount of diodrast through this channel into the common hepatic bile duct. (Fig. 6A.) If the ducts are normal and the diodrast flows into the duodenum, the abdomen can be closed without any misgivings. (Fig. 6B.) Should intraductal stones or ampullary strictures be encountered, these can be corrected.

It is surprising how often the lumen of the cystic duct has been obliterated by a progressive fibrosis and, therefore, cannot be utilized as a portal for introducing the diodrast. If such conditions are encountered, the diodrast is injected directly into the lumen of the choledochus or the common hepatic bile ducts.

*Ampullary Injections (Retrograde Cholangiograms).* Sometimes considerable difficulty is experienced in locating the common bile duct, particularly in the presence of inflammatory strictures, persistent external biliary fistulas and in infants having atresia of some segment of the biliary system. It is a simple matter to open the duodenum, expose the papilla vater and to cannulate the same. (Fig. 7A.)

Diodrast can be forced up along the distal end of the choledochus until the entire biliary system has become filled. The radiographic pattern clearly visualizes the nature and extent of the reconstructive problem confronting the operator. (Fig. 7B.)

Retrograde choledochograms are particularly useful in locating the distal end of a collapsed common bile duct. Such pathologic conditions are found when the common bile duct has been severed or accidentally ligated. In such conditions the external biliary fistula usually drains the common hepatic duct; by introducing the diodrast into the fistulous tract an exact pattern of the common hepatic and intra-hepatic ducts is obtained. The common bile duct, however, is collapsed and can be easily located by using retrograde choledochograms. Not only does one obtain an accurate idea of the position of the choledochus but when it is distended with diodrast the duct can be easily palpated. These procedures have been of great value to us in reconstructive operations on twelve patients suffering from traumatic severance of the common bile duct.

*Completion Cholangiograms.* Whenever the common bile duct has been opened and offending stones have been removed, the operator is always desirous of knowing whether all of the troublesome calculi have been removed and if the ampullary orifice is patent so the bile can flow into the duodenum. Such information should be obtained on the operating table. This can be accomplished by introducing the diodrast directly into the common bile duct through the drainage catheters and taking a radiograph. If the ducts are functioning in a normal manner, nothing further need be done. If, however, the cholangiogram reveals several residual shadows indicating the presence of stones, the "T" tube should be removed and the ducts re-explored for the elusive calculi. (Fig. 8.) On several occasions it has been necessary to reopen the common bile duct and remove overlooked stones.

When performing a cholecystostomy for

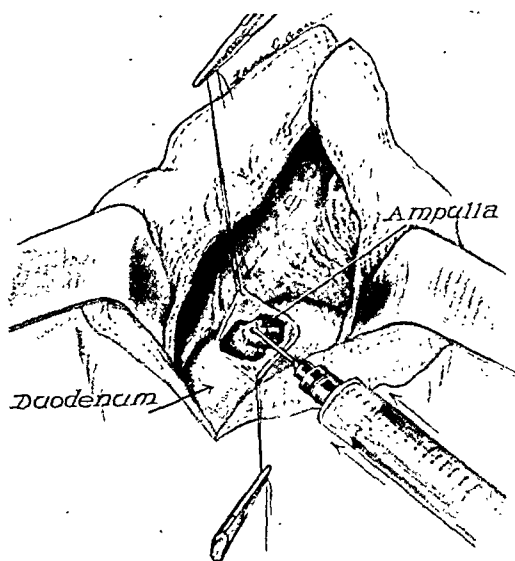


FIG. 7A



FIG. 7B

FIG. 7. A, method for utilizing the ampulla of Vater as a portal for introducing the diodrast. The duodenum has been opened and a small silver cannula is inserted into the ampulla of Vater; 20 cc. of diodrast is injected into the common bile duct. B, this retrograde choledochogram reveals the upper segment of the choledochus to be dilated and the negative shadow localizes the offending stone. Note that the distal end of the common duct is collapsed and, hence, could not be palpated. The stump of the cystic duct is dilated and contains one large stone. This patient had had a cholecystectomy six months previously and ten stones were removed from the common bile duct at that time.

decompression of an obstructed biliary system, it is imperative that the surgeon test the patency of the cystic duct before closing



FIG. 8. Completion choledochogram; the common bile duct had been opened and four facted stones were removed. Instrumental exploration indicated all calculi had been removed. A "T" tube was sutured into the common duct and then 20 cc. of diodrast (70 per cent) was injected into the duct through the catheter. Note the dilatation of the choledochus and the complete ampullary obstruction caused by the two large stones. The "T" tube was removed and the stones were extracted. A second completion cholangiogram demonstrated the choledochus to be patent so the abdomen was closed. This completion cholangiogram saved the patient another operation.

the abdomen. Best and Hicken<sup>2</sup> have presented evidence to show that when the cholecystostomy fails to relieve extrahepatic jaundice it means the cystic duct has been closed by undetected stones, strictures or kinks. Drainage is ineffective under such circumstances. Completion cholangiograms determine the efficiency of the decompressive operation. This is accomplished by injecting 50 cc. of diodrast into the cholecystostomy tube and have a cholangiogram made. If the diodrast has been able to pass from the gallbladder through the cystic duct into the larger bile ducts, it seems reasonable to believe that bile can follow this same channel and escape through the drainage tube. Should the cholangiogram demon-

strate an obstruction of the cystic duct, some other method of decompression must be adopted. All of this can be accomplished while the patient is still on the operating table.

The completion cholangiogram affords an excellent method of determining the exact position of the drainage tubes. Several times we have observed that the proximal limb of the "T" tube has been threaded into the right hepatic duct providing adequate drainage for the right lobe of the liver but the solid portion of the tube has obstructed the orifice of the left hepatic duct, thereby effecting an obstruction of the left hepatic lobule. When such conditions are detected, immediate correction is possible before closing the abdomen.

#### COMMENTS

Operative cholangiography provides much essential information concerning the anatomic, physiologic and pathologic conditions of the extrahepatic biliary system. However, it is not employed as a routine measure in all operations on these structures. Unfortunately, there are several problems which must be solved before general acceptance can be hoped for.

In the first place, both the radiologist and surgeon must be conversant with the radiographic patterns of the biliary tract before they can appreciate or detect existing abnormalities. Unfortunately, interpretative experiences are so limited that only a few radiologists will hazard to evaluate a cholangiogram. Similar difficulties were encountered when pyelography and encephalography were introduced but an educational program combined with actual experience soon placed these diagnostic procedures on a firm basis. The same pattern must be followed if the full value of cholangiography is to be realized.

Again, many surgeons honestly believe that palpatory and instrumental exploration of the bile ducts will locate all intra-ductal stones, hence, cholangiography is unnecessary. Our experiences have been to the contrary. One has but to read the cur-

rent literature to be convinced that the elusive common duct stone is frequently overlooked.<sup>12</sup> Pribram<sup>13</sup> and many others have devised methods of dissolving choledochal stones which were missed at the primary operation. If routine postoperative cholangiograms are made on all patients having drainage tubes in the common bile duct, it will be surprising to note the large number of residual stones.<sup>7</sup> Fully 95 per cent of all secondary operations we perform on the biliary tract are for overlooked intraductal stones. In all fairness it must be admitted that we have missed stones when using operative cholangiograms but these errors were due to faulty interpretation of the cholangiograms and experience will most certainly reduce such mistakes.

Objections have been made that the increased time required to obtain the cholangiogram prolongs the operation thereby increasing the hazard to the patient. Experience and a well planned routine eliminates such criticisms for we have found that our operative time actually has been decreased by eliminating unnecessary ductal explorations and time-consuming palpatory examinations.<sup>14</sup> The actual time required for the introduction of the contrast solution and taking the cholangiogram is less than three minutes. While the film is being developed, the operator can ligate bleeders and proceed with his operation, hence, there is no delay.

#### SUMMARY

1. Operative cholangiography is a means of visualizing the extrahepatic biliary system by contrast roentgenography during the surgical exploration of these structures. If the gallbladder and bile ducts are filled with a suitable contrast solution, an accurate radiographic pattern of the entire extrahepatic biliary system can be obtained. Pathologic lesions such as stones, kinks, strictures and neoplasms produce recognizable deformities. Anatomic aberrations in size, shape and position of the bile duct can be readily detected. This information is necessary for the judicious selection of the proper remedial operation.

2. The surgical and radiographic technic of operative cholangiography is presented in detail.

3. During the past fourteen years we have employed operative cholangiography in all patients having operations on the extrahepatic biliary system. More than 1,700 studies have been made and the advantages of this procedure are presented.

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# ACUTE NON-TRAUMATIC SPINAL EPIDURAL HEMORRHAGE\*

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**H**EMORRHAGE into the spinal extradural space is an uncommon cause of sudden cord compression with paraplegia. If trauma to the spinal cord or demonstrable specific diseases associated with increased bleeding tendency are excluded as etiologic factors, its occurrence is a rarity. To avoid a permanent paraplegia or, at times, a rapid fatality, the recognition of spinal epidural hemorrhage must be considered a neurologic and neurosurgical emergency as grave as the intracranial traumatic variety.

Epidural hemorrhage is encountered occasionally with severe back injuries. Subarachnoid or intramedullary bleeding is a frequent accompaniment in these instances. Fractures and dislocations of the spine, direct blows or falls on the back, stab and gunshot wounds, birth injuries, indirect injury from striking either end of the vertebral column and, rarely, the awkward performance of a spinal tap have been reported as traumatic causes of this form of localized bleeding. Non-traumatic spinal epidural hemorrhages have been discovered with blood dyscrasias, such as hemophilia, purpura, leukemia; with systemic illnesses such as typhoid fever, scurvy, smallpox; in company with vertebral disease or rupture of an aortic aneurysm; and in rare instances of syphilitic vascular disease. In the vast majority of these non-traumatic forms the epidural bleeding was an incidental finding among the more widespread disease manifestations.

Acute non-traumatic spinal epidural hemorrhage of unknown etiology, from the reports in the literature, has an ex-

ceptionally low incidence. Shenkin, Horn and Grant<sup>10</sup> in an exhaustive review of fifty-four epidural compressive lesions of the cord at the University of Pennsylvania Hospital during the ten-year period from 1934 to 1944 included two such cases, an incidence of 3.7 per cent of the epidural lesions which in turn represented 30 per cent of the total number of mass lesions within the spinal canal.

During the last three years two cases of acute non-traumatic spinal epidural hemorrhage of undetermined etiology have been observed on the Neurological Division at Bellevue Hospital.

## CASE REPORTS

**CASE 1.** F. C., a thirty-nine year old woman, was admitted to the Bellevue Hospital Neurological Division on August 6, 1947, with the complaints of epigastric pain, vomiting, numbness and paralysis of both legs for three days. Ten days before admission she had a sharp pain on the medial aspect of the left leg below the knee. This disappeared in two days and she was then without symptoms until three days before admission on August 3, 1947. On this day she experienced epigastric pain lasting a short while and completely relieved by rhubarb and soda. On the following day at 11:30 A.M. there was a recurrence of severe epigastric pain, belching, nausea and vomiting associated with severe mid-back pain, numbness in the lower part of her legs and inability to walk. Within three hours a complete paraplegia developed with an upper abdominal level. She was admitted to Gouverneur Hospital that evening and remained there for two days before her transfer to Bellevue Hospital. At Gouverneur Hospital she continued to complain of epigastric pain, nausea and vomiting and had to be catheterized

\* From the Neurological Service (Cornell Division), Bellevue Hospital, New York, N. Y. Read before the Section of Neurology and Psychiatry of the New York Academy of Medicine, February 10, 1948.

for urinary retention. A lumbar puncture was attempted but because of her obesity the puncture was traumatic and unsuccessful.

Episodes of right upper quadrant and epigastric discomfort with eructations and subjective "bloating" were first remarked by the patient six years before admission. These symptoms almost invariably followed the ingestion of fried or fatty foods and recurred about once monthly without specific relation to menstrual periods. The gastrointestinal symptoms immediately preceding the onset of the paraplegia were considered by the patient as typical of one of these attacks. A cesarean section had been performed eight years before admission but the remainder of the past and family history was non-contributory.

General physical examination revealed the following: temperature 101°F., pulse rate 100, respiratory rate 12 and blood pressure 130/86. The patient was very obese, vomited almost continuously and produced small amounts of bile-stained vomitus. There was a second degree burn on the back in the region of D8. This had resulted from the inept application of a hot water bag before her admission to the hospital. There was slight epigastric tenderness. Pelvic examination revealed uterine fibroids.

Neurologic examination revealed that the sensorium was clear. Cranial nerve functions were normal and the neck was supple. There was moderate tenderness on pressure over the spinous processes from D<sub>5</sub> to D<sub>9</sub>. The upper extremities were normal. There was a complete flaccid paraplegia of the lower limbs with retention and overflow incontinence of urine and feces. No atrophy or fibrillations were observed. Deep tendon reflexes were absent in the lower extremities with no Babinski toe signs. There were bilateral Hoffman signs. Superficial abdominal reflexes were absent in the lower segments, present, equal but underactive in the upper segments. Sensory examination disclosed absence of pain, touch, temperature, vibration and position sensation below the level of D8, with moderate impairment in these sensory forms for one dermatome above this level and unimpaired sensation of the remainder of the body.

Laboratory data were reported as follows: Urinalysis showed 1+ albuminuria, 20 white cells per cu. mm., and many bacteria, undoubtedly the result of a mild cystitis from

urinary retention. Hemoglobin was 14 Gm. White blood cells were 12,200 on admission but down to 7,500 in several days, with normal differential. Bleeding and clotting times were normal. The capillary fragility and blood Mazzini tests were negative. Blood non-protein nitrogen was 40 mg. per cent; fasting blood sugar was 97 mg. per cent; total protein was 6.2 Gm. per cent with albumin-globulin ratio of 3.8/2.4; icteric index 10, cephalin flocculation test negative. Blood phosphorus was 2.36, alkaline phosphatase 3.0 units. Lumbar puncture revealed slightly xanthochromic fluid with initial pressure of 190 mm. water. Manometric studies revealed a partial block with slow rise and fall after jugular compression. Spinal fluid protein, was 180 mg. per cent, sugar 83 mg. per cent, chlorides 705 mg. per cent, Wassermann test negative. Roentgenograms of the vertebral column were within normal limits.

Because of the suddenness of the onset of a complete paraplegia with evidence of cord compression a diagnosis of vascular accident (hemorrhage), possibly into a pre-existing spinal cord neoplasm, was made. Laminectomy was, therefore, performed on the morning of August 8, 1947. Laminae from D<sub>4</sub> to D<sub>7</sub> were unroofed, and a hemorrhagic mass was found in the epidural space at D<sub>5</sub> and D<sub>6</sub>. This mass was removed completely from the posterior and lateral surfaces of the dura; after hemostasis was obtained with some difficulty, the dura and underlying cord were pulsating well. Pathologic examination of the removed tissue revealed clotted blood with fibrin and few inflammatory cells, with no evidence of neoplasm. During a twenty-week period of observation since surgery there has been no recovery of function in the lower limbs.

CASE II. D. G., a forty-three year old man, was admitted to Lenox Hill Hospital on April 1, 1946, with the complaint of sudden paralysis of both lower limbs. On March 21, 1946, ten days before this hospital admission while shaving he experienced a sudden sharp pain in the region of the lower lumbar spine. This became intense and agonizing in a few minutes and began to radiate down the posterior aspect of both thighs to the level of the knees. He was admitted to Huntington Hospital, Long Island, that same day. During the course of a few hours he had rapidly increasing weakness of both legs, progressing to a com-



plete paraplegia in three days. He was transferred to Lenox Hill Hospital on April 1, 1946.

Fifteen years before this illness he strained his back when he attempted to lift a heavy weight. At this time he had an attack of lumbar pain similar in location to this severe episode but much milder in intensity. The pain disappeared in a few days and was not accompanied by weakness or sensory changes. During the intervening years he had had three or four similar transient attacks of back pain.

Neurologic examination revealed a complete paraplegia with absence of sensation in all forms below the level of D12. X-rays of the dorsolumbar spine showed slight irregular sclerosis of the body of the twelfth dorsal vertebra but no other bone or joint disturbance. A pantopaque myelogram was performed on April 2, 1946, and revealed almost complete obstruction to the flow of the opaque medium at the level of the inferior border of D12.

Laminectomy was performed on April 2, 1946. Upon exposure of the epidural space a reddish-brown, firm-looking sheet of tissue, approximately 10 by 3 by 3 cm. was disclosed along the dorsal aspect of the dura and partially encircling it, particularly at the level of L1. The upper portion of this mass extended to D9. The tissue could not be identified grossly at operation and a frozen section was reported as negative for tumor tissue. Final pathologic diagnosis was hemorrhagic mass with fibrin and a few inflammatory cells.

Following operation he had return of sensation in both legs without return of motor function. However, sensation became progressively impaired during later convalescence and at the time of admission to Bellevue Hospital on March 27, 1947, the loss of sensation was similar to that observed preoperatively. At the time of this report the paraplegia is complete, with a sensory level at D12. Lumbar puncture on April 2, 1947, revealed an initial pressure of 50 mm. of water, clear, colorless fluid, spinal fluid protein of 48 mg. per cent and a negative Wassermann test. Manometric studies showed no evidence of block. Bladder control is his main problem although rehabilitation with braces and crutches has been accomplished.

#### COMMENT

A total of ten cases of acute spinal epidural hemorrhage, including the two presented in this report, have been reported

in the literature. Although each case is classified as non-traumatic in origin, several<sup>6,8,9,12</sup> had specific minor injuries associated with the onset of symptoms. Each of these four patients (Cases 7 to 10 in Table 1) had minor falls without direct injury to the back. The absence of fracture-dislocation by roentgenographic or operative demonstration was considered by the authors as evidence that the relatively minor trauma played no major etiologic role. For this reason and because of the type of precipitating etiologic factors in the other cases, all have been grouped together for comparison in Table 1.

The age of onset varied from twenty months to seventy-five years. Eight of the ten cases, however, occurred in the age group between eighteen and forty-three years. This relatively young age incidence is informative in differentiating the entity of spinal epidural hemorrhage from sudden paraplegia secondary to metastatic cord lesions. There was no sex difference in the series of ten patients.

Although specific direct or indirect trauma to the back was not recorded in the first six cases in Table 1, some form of precipitating straining effort was reported in all but two instances. One of the two was a twenty months old infant whose epidural hemorrhage accompanied an acute infection in which the possibility of increased bleeding tendency was not completely excluded. The type of straining effort varied. Straining at stool was reported by Bain.<sup>1</sup> Hopkins<sup>7</sup> patient suddenly lunged forward while he was shoveling coal. A sudden twist in bed was mentioned in one of the two cases reported by Shenkin, Horn, and Grant.<sup>10</sup> Severe vomiting during an attack of cholecystitis preceded the paraplegia in Case 5 (Table 1), while the patient in Case 6 experienced symptoms while he was shaving, with no history of any form of straining effort or minor injury at the onset.

Back pain, sharp and severe, and at the approximate level of the pathologic lesion was recorded as the first symptom in six of the ten reported cases of acute spinal

epidural hemorrhage. In five of these six cases associated radicular pains were present. The interval from the onset of the first symptom to the development of a complete paraplegia varied from twenty minutes to ten days, but 50 per cent of the

toms and the others four days later. The location of the epidural hemorrhage in two of these three fatal cases was in the upper cervical region. However, there is no cord level particularly vulnerable to this type of lesion, the distribution in the

TABLE I

Authors	Age	Sex	Activity at Time of Onset	Back Pain	Interval		Level of Lesion	Course
					Onset to Paraplegia	Paraplegia to Surgery		
1. Bain <sup>1</sup> 1897.....	18	F	Housemaid, straining at stool	+	2 hr.	.....	C2-3	Quadriplegia in 2 hours, fatal
2. Hopkins <sup>7</sup> 1899..	40?	M	Shoveling coal	+	20 min.	.....	Lumbar	Fatal 4 days after onset
3. Shenkin et al. <sup>10</sup> 1945	20 mos.	?	Acute infection	?	10 days	?	Upper dorsal	Complete recovery 1 yr. after operation
4. Shenkin et al. <sup>10</sup> 1945	42	M	Sudden twist in bed	?	2 hr.	> 1 wk.	D5-6	No recovery 1 year after laminectomy
5. Kaplan 1947....	39	F	Vomiting with cholecystitis	+	3 hr.	4 days	D5-6	No recovery 12 weeks after laminectomy
6. Kaplan 1947....	43	M	Shaving	+	3 days	8 days	D12-L1	No recovery 1½ years after laminectomy
7. Hassin et al. <sup>6</sup> 1935	32	F	Minor fall because of limping gait	-	2 days	10 days	D10	Improved for 2 weeks, then expired postoperatively
8. Jonas <sup>5</sup> 1911....	35	M	Farmer, fell from haystack	-	24 hr.	10 days	D5-6	Recovered leg function after surgery; no fracture-dislocation
9. Reid et al. <sup>9</sup> 1925.	20?	F	Trivial fall from bicycle	+	24 hr.	.....	C3 to lumbar	Expired in 4 days, no fracture-dislocation
10. Ver Bruggen <sup>12</sup> 1946	75	M	Fell 4 to 5 feet, striking buttocks	+	few hr.	?	C5-6	Almost complete recovery in several weeks

patients were completely paralyzed below the level of their lesion within three hours of the onset of complaints. The time interval from the development of the paraplegia to surgical intervention was not indicated in five of the ten cases but the shortest was four days (Case 5 Table I). This represents a delay occasioned by diagnostic difficulties and perhaps accentuates the urgency of exploratory laminectomy in any such catastrophic level lesion suggesting cord compression.

Three of the ten reported cases were fatal before surgical intervention, one within a few hours of the onset of symp-

reported cases sparing no region. Of the total of ten cases, two were upper cervical in location, one lower cervical, one upper thoracic, three mid-thoracic, one lower thoracic, one thoraco-lumbar and one lumbar.

The results of surgery are obviously not statistically significant in this small series of cases. Three of the seven surgically-treated patients recovered completely or almost completely after removal of the blood clots. No recovery of lower limb function was noted in the remaining four cases although follow-up periods extend from fourteen weeks to one and one-half

years. One of these patients Case 7 (Table 1) expired two weeks postoperatively.

The differentiation of acute spinal epidural hemorrhage from other sudden non-traumatic spinal cord insults may not be possible on clinical grounds. Hemorrhage into a pre-existing intra- or extramedullary neoplasm or into a syringomyelic cavity has most often been preceded by warning symptoms. Acute epidural infection, usually accompanied by roentgenographic evidence of vertebral osteomyelitis, may also be distinguished by the systemic signs of inflammatory disease. Demonstration of a partial or complete spinal fluid manometric block will serve to exclude processes such as acute transverse myelitis, hematomyelia without edema and anterior spinal artery thrombosis. Dissociation of sensory findings in cases of hematomyelia and confinement of the pathologic changes to the ventral two-thirds of the cord in anterior spinal artery thromboses differentiate these two syndromes from epidural hemorrhage. Cord dysfunction resulting from the nebulous element of "spinal shock" which occurs after many acute lesions undoubtedly requires exploratory laminectomy as the diagnostic as well as therapeutic procedure in all questionable cases.

Speculation about the etiology of non-traumatic or "spontaneous" spinal epidural hemorrhage has not been aided by convincing pathological evidence. Bleeding into the spinal epidural space is usually venous in origin, and it is our belief that the source of the focal epidural hemorrhage is some form of vascular anomaly of the epidural venous plexus. Rupture of such vascular abnormalities by minor straining efforts may be explained logically by a consideration of the physiologic anatomy of the epidural venous system.

The space commonly referred to as epidural in the spinal canal does not correspond strictly to the intracranial epidural space. The former is actually an "intradural" space. In the intracranial cavity the dura consists of two adjacent membranous layers, closely approximated, with a potential space between them except

where they are separated by the intracranial venous sinuses. The venous sinuses, therefore, occupy this so-called "intradural" space. Epidural hemorrhages resulting from trauma to the cranium occur external to both dural layers. In the region of the foramen magnum the two dural layers diverge, the outer one becoming continuous with the periosteum of the inner surface of the vertebral column. The inner dural layer is then the recognizable dural covering of the spinal cord when the laminae are reflected. Similar in location to the intracranial venous sinuses and continuous rostrally with them is the epidural plexus of veins. The epidural veins lie in the loose network of epidural aerolar and adipose tissue. They are formed from small venous tributaries passing with the spinal nerve roots through the intervertebral foramina. These, in turn, are continuous with the posterior vertebral venous plexus and, thereby, with the pelvic venous system. The subarachnoid-pial veins connect with the epidural venous plexus along the nerve roots penetrating dura.

The clinical anatomy of the vertebral veins has been a subject of study in recent years. Work by Batson,<sup>2</sup> Bock,<sup>3</sup> Cruveilhier,<sup>4</sup> and Norgore<sup>5</sup> has resulted in the demonstration of a fourth system of veins, namely, the vertebral or meningeo-rachidian system in addition to the caval, portal and pulmonary systems. The epidural veins and plexuses comprise the main portion of this vertebral venous system. Serial x-rays of the body following the injection of a dye (water color vermilion) into the dorsal vein of the penis demonstrated a flow of the injected material through the veins along the pelvic girdle, along and within the vertebral column and, finally, inside the cranial cavity, by-passing the vena cava. The posterior vertebral and epidural veins are of the primitive type, have no valves and carry blood at considerably lower pressures than the caval venous system. This increases the freedom of venous circulation and facilitates the reversal of venous flow under certain circumstances, such as posture, coughing,

sneezing and straining. The anatomic "rediscovery" of the vertebral venous system resulted from efforts to explain "paradoxical metastases" from pelvic neoplasms, particularly carcinoma of the prostate. It provides an explanation for intracranial and vertebral metastatic lesions without involvement of lung parenchyma. The existence of a fourth venous system explains also the mechanism by which blood may return to the heart after occlusion of large venous structures, such as the femoral or iliac veins.

Vascular abnormalities of the spinal cord have been classified into five groups by Wyburn-Mason.<sup>13</sup> These are: (1) venous abnormalities, including varicosities (angioma racemosum venosum) and secondary venous changes occurring below a compressing cord lesion; (2) arteriovenous angiomas; (3) arterial anomalies (aneurysms); (4) syphilitic aneurysms and (5) telangiectases. The two types of vascular abnormalities found in the epidural space are varicosities and telangiectases. Turner and Kernohan,<sup>11</sup> in a pathologic study of forty-six cases of vascular malformations and tumors of the cord, included three cases of epidural varices, none of which type was seen by Wyburn-Mason. In addition, of course, are the true extradural vascular tumors, such as the hemangioblastoma.

It is probable that a straining effort, increasing intra-abdominal and intrapelvic pressure, causes a rise of pressure and reversal of flow in the epidural venous system. Hypothetically, rupture of a weakened vascular wall in some form of epidural venous abnormality may account for acute, non-traumatic spinal epidural hemorrhages.

#### SUMMARY

Two cases of acute non-traumatic spinal epidural hemorrhage are reported. Eight additional cases, four of which had a history of minor indirect trauma, have been collected from the literature. In spite of the apparent rarity of the syndrome awareness of its existence should lead to prompt

surgical intervention in an effort to avoid permanent paraplegia.

Although the etiology of the non-traumatic form of spinal epidural hemorrhage remains obscure, certain factors suggest that rupture of a weak vascular wall in a pre-existing abnormality of the epidural venous plexus may be the pathogenetic mechanism of this acute spinal cord syndrome. These factors are: (1) pathological evidence of the focal occurrence of two types of vascular abnormalities, venous varicosities and telangiectases in the epidural space; (2) the clinical anatomy of the vertebral venous system, in which the absence of valves permits rapid transmission of increased venous pressure from intra-abdominal and pelvic veins to epidural veins; and (3) the history of some form of straining effort immediately preceding the onset of symptoms in eight of the ten reported cases of spinal epidural hemorrhage.

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# BASIS FOR PLANNED MANAGEMENT IN INTESTINAL OBSTRUCTION\*

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**S**IMPLE intestinal obstruction does not always require relief by surgical means. In many instances obstruction has been overcome following a period of planned management designed to relieve the patient of the effects of vomiting and to relieve the intestinal canal of distention, with its effects on the general condition of the patient and the local condition in the bowel. This planned management has been called conservative therapy but it is not opposed to surgery when the latter is indicated. Obstruction which accompanies or follows acute inflammation within the abdomen may be relieved by treatment directed toward overcoming the inflammatory process. The use of antibiotics or sulfonamides and intravenous infusions of blood, dextrose, proteins and minerals with drainage of an abscess when indicated frequently relieves obstruction. When adhesions following one or more abdominal operations are the cause of obstruction, a period of conservative management may be followed by complete relief, thereby avoiding the addition of more adhesions by another operation. In some instances, using the same conservative means, complete obstruction in a sick patient may be converted into an incomplete obstruction and permit improvement in the patient's condition before surgery is undertaken; while in others sufficient improvement may occur to permit preparation of the patient for what may be an extensive or serious operation in spite of the persistence of the complete obstruction.

Thus conservative management of simple intestinal obstruction is not only a therapy for the condition but also a means

of preparation of the patient for the surgical relief of obstruction when this is found to be necessary. The time required for successful conservative therapy is not important so long as satisfactory progress is being made. However, persistence in this form of management *without* evidence of improvement, such as deflation of the bowel with a return of normal peristalsis, is hazardous and surgery must not be deferred. Conservative management must not be confused with neglected or delayed management which favors disabling complications or death. Surgery without delay is especially urgent in strangulation obstruction. In closed loop obstructions of the large bowel immediate decompression is necessary and surgery should be done when it is found that rectal or colonic irrigations do not relieve the obstruction.

The illness of the patient in acute intestinal obstruction varies in intensity with the grade of the obstruction (complete or incomplete), its duration, its level in the intestinal canal (high, intermediate or low) and the extent of vascular impairment in the involved section of bowel. These factors determine (1) the amount of fluid and mineral loss through vomiting or stagnation in the intestinal lumen; (2) the extent of intestinal distention; (3) the severity of toxemia and infection which follows gangrene (actual or impending) of the involved bowel; and (4) the blood changes associated with shock, uremia, alkalosis, acidosis, hypohydration, etc. All of these factors play a role, to a greater or lesser extent, in the production of symptoms following obstruction due to any of the large variety of pathologic lesions responsible for inter-

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ference with the passage of intestinal contents distally in the intestinal canal.

*Duration.* A thorough analysis of the history of the patient's complaint, a complete physical examination and the necessary laboratory work frequently aid in

understood following a review of the functional anatomy of the intestinal tract. The gastrointestinal canal embryologically is divided into three divisions: the foregut, the midgut and the hindgut. (Fig. 1.) Anatomically the foregut is that portion of

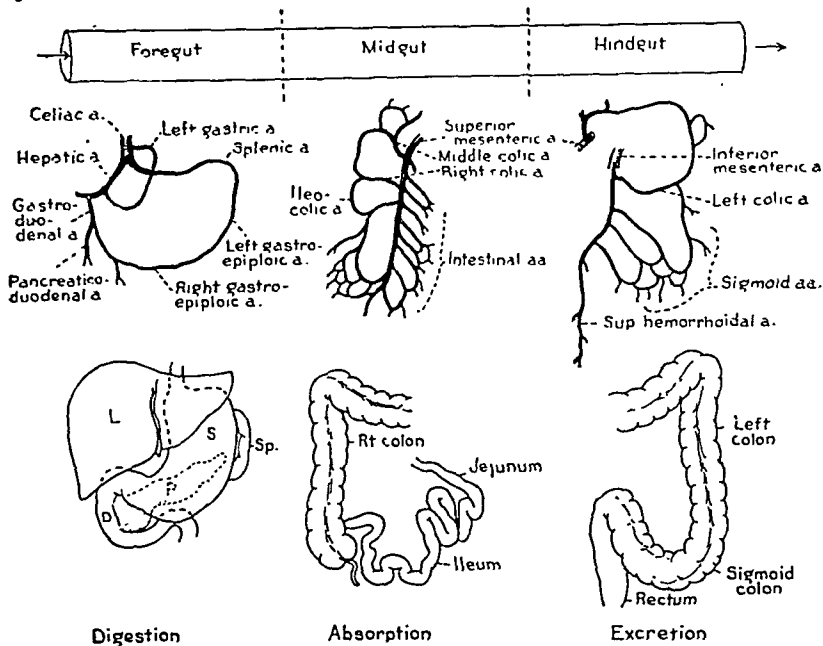


FIG. 1. The three embryologic divisions of the gastrointestinal tract are delimited by the distribution of three vessels from the abdominal aorta. The foregut supplied by the celiac axis is concerned with the process of digestion. The mid-gut supplied by the superior mesenteric artery is concerned with the process of absorption. The hindgut supplied by the inferior mesenteric artery is concerned with excretion of the non-absorbed residue.

establishing the correct diagnosis before irreversible changes take place. The longer the duration the more extensive became the changes in blood and body tissues and the less effective became the propulsive and constrictive efforts of the intestinal musculature. When the blood supply to the bowel is involved, the more certain is the danger of necrosis, peritonitis, shock, toxemia and sepsis. Immediate relief is imperative.

In the presence or absence of strangulation the prompt institution of correctional therapy as outlined herein will obviate many of the unfavorable consequences of prolonged interference with the flow of intestinal contents.

*Level of Obstruction.* The variation in symptoms due to obstruction at different levels in the intestinal canal may be better

the digestive tract which receives its blood supply from the celiac axis of the aorta. Physiologically, these organs are concerned with the processes of digestion.

Anatomically, the midgut receives its blood supply from the superior mesenteric artery. The organs supplied by this vessel are the jejunum, ileum and right half of the colon. (Fig. 2.) Physiologically, this portion of the intestinal canal is concerned with absorption. The process of absorption involves the selection of food substances in a relatively dilute state from the intestinal canal. If there is but a small amount of fluid available, absorption may be decreased or delayed since the passage of materials from the lumen to the blood stream is a function of the osmotic tension of the solutes in the bowel and that of the blood in the intestinal vessels. Therefore,

it is necessary for a large amount of water to be secreted into the intestinal lumen. This phase of absorption, dilution of food, is made possible by the secretion of succus entericus into the jejunum. The jejunum has a very extensive arterial supply which furnishes the blood necessary for the pro-

maining in the ileum. The third portion of the midgut is the right half of the colon. This portion of the bowel absorbs water and salts. Thus there is no loss of the materials which are secreted into the intestinal canal for the purpose of preparing food for absorption.

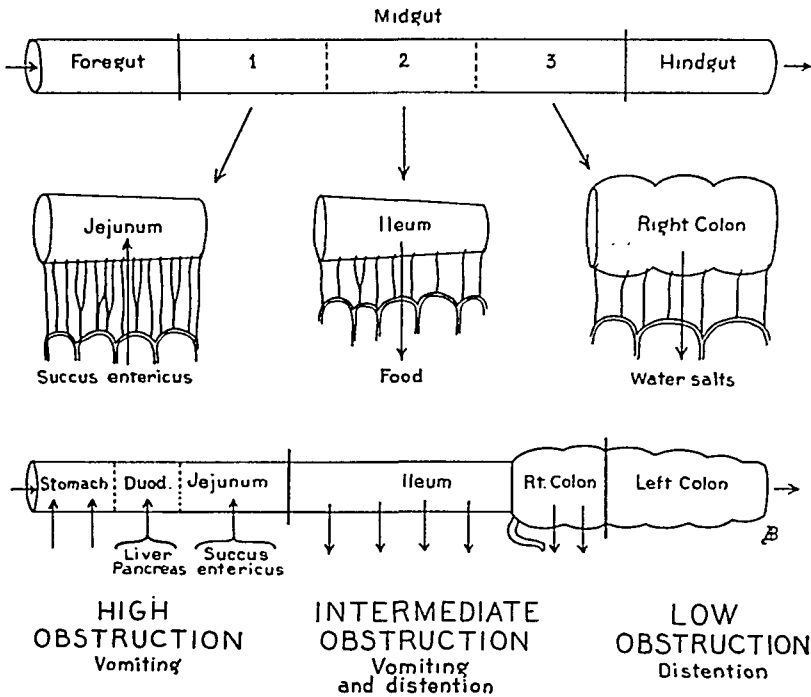


FIG. 2. The mid-gut includes the jejunum, ileum and the right half of the colon. The jejunum is large in caliber and thick-walled with many vessels to supply the fluid needed for succus entericus. A rapid peristalsis carries this fluid and the food with which it is mixed to the ileum. Here absorption occurs and the residual fluid is taken up by the right half of the colon. Thus the high obstruction occurs in that part of the intestinal canal in which absorption is minimal. The low obstruction occurs in the hindgut after food and water have been absorbed. The intermediate obstruction lies between the former two.

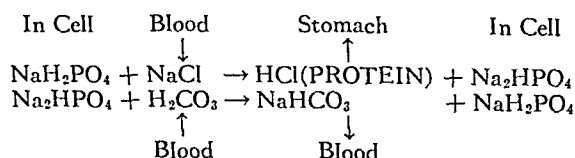
duction of succus entericus. Physiologically, little absorption of water or salt occurs here. The second portion of the midgut is the ileum. In the ileum most of the food is actually absorbed. It is well known that chronic diseases involving the ileum are frequently associated with nutritional disturbances such as anemia and hypovitaminosis. While the ileum may absorb large quantities of water and salts, this would be disadvantageous since absorption of water here would concentrate the intestinal contents and diminish absorption of the nutritional elements re-

Anatomically, the hindgut is supplied by one blood vessel, the inferior mesenteric artery. It includes the left half of the colon, sigmoid and rectum. The function of the hindgut is to store the non-absorbed residue of the intestinal contents and at intervals to expel this material from the intestinal canal.

The foregut and the first portion of the midgut have secretions poured into their lumens. Below the jejunum absorption removes fluid from the intestinal canal. Intestinal obstruction in the jejunum prevents the passage of secretions to the

absorptive portion of the intestinal canal. These secretions either stagnate or are removed by vomiting. Obstruction above this level is called high intestinal obstruction. Obstruction below the level of the jejunum leaves a progressively longer portion of the intestinal surface available for absorption. Obstruction in the absorptive portion of the intestinal canal may well be called intermediate intestinal obstruction. Obstruction in the left half of colon does not interfere with absorption of the fluids poured into the intestinal canal. While there may be no immediate loss of fluids from the body, the primary difficulty is the inability to expel the non-absorbed residue. This results in distention which is characteristic of low obstruction. In high obstruction intestinal secretions cannot be absorbed. In low obstruction absorption may occur with but slight impairment for a long period of time. It is clear, then, that high obstructions are most serious since the patients become ill sooner from loss of fluids and salts and the symptoms are more pronounced. In these patients who have low obstruction many days may pass with few symptoms.

**Vomiting.** Obstruction above the ampulla of Vater results in vomiting with loss of gastric secretion. The loss of water and chlorides results in chemical changes in the circulating blood. Hydrochloric acid formation in the stomach is associated with a decrease in chlorides and replacement of carbonic acid with bicarbonate in the blood stream. The following formula indicates the probable mechanism of hydrochloric acid formation:



The hydrochloric acid in the gastric cell is not free (lest corrosion of the tissues takes place) but is liberated from its combined protein by the action of chloresterase in the lumen of the stomach.

Normally the chlorides secreted into the stomach are returned to the blood stream by absorption from the intestinal canal. Chlorides lost in the urine and sweat are replaced by salt in the ingested food. The bicarbonate resulting from hydrochloric acid formation appears in the pancreatic and intestinal secretions and in the urine (alkaline tide). When absorption is impossible, as in high obstruction, vomiting prevents the absorption of chlorides secreted in the stomach and prohibits ingestion of chlorides present in food. This results in blood changes characterized by a decrease in blood chloride, an increase in blood bicarbonate and a shift in the blood pH toward greater alkalinity. If this condition continues, the blood changes may become profound and give rise to alkalosis. This condition is characterized by an increase in non-protein and urea nitrogen in the blood and, if progressive, uremic symptoms may develop.

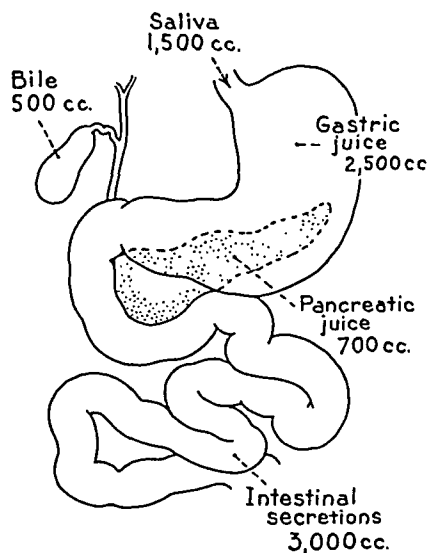
Vomiting following obstruction lower in the intestinal canal removes gastric secretion, pancreatic secretion, bile and succus entericus. (Fig. 3.) This is associated with a loss of water, carbonates, bicarbonates and sodium. Definite blood changes occur. There is a decrease in blood bicarbonate, a shift in the blood pH to decreased alkalinity and a decrease in blood sodium.

The tissues lose their capacity to hold water because of the loss of sodium. In the past many of the symptoms resulting from these losses were attributed to toxemia. It appears that the symptoms are more likely due to the pathologic state associated with the blood changes which follow excessive vomiting. It has been pointed out that the most constant change and the one which gives the best index of the true condition of the patient is the elevation of blood urea. This results not only from vomiting but also from the increased metabolism of endogenous protein which occurs in the presence of intestinal obstruction. The loss of chloride varies with the amount of vomiting. The level of the carbon dioxide combining power is variable but in general



in the presence of decreased chlorides it is elevated (alkalosis) and in the presence of normal values for chloride it is normal or decreased (acidosis). Under the influence of satisfactory treatment, whether conservative or surgical, the blood chemical

of vomiting and fluid stagnation. Under normal circumstances the average individual excretes from 5 to 10 Gm. of sodium chloride daily depending on his or her activities, occupation, natural habits of diet, etc. When no salt is ingested, urinary



Secretion	Vol.	NaCl.
Saliva	1,500 cc.	7 gms.
Bile	500 cc.	7 gms.
Gastric juice	2,500 cc.	15 gms.
Pancreatic juice	700 cc.	8 gms.
Intestinal secretions	3,000 cc.	18 gms.
	8,200 cc.	55 gms.
Total plasma volume	3,500 cc.	23 gms.

FIG. 3. The volume of secretions and sodium chloride content derived from the gastrointestinal canal; continuous absorption is necessary to maintain the plasma volume. Loss of secretions from the gastrointestinal canal is reflected in the loss of plasma volume and blood chlorides.

values return to normal, the urea usually more slowly than the other values.

In view of this the first indication for therapy when vomiting occurs is the replacement of the materials lost both qualitatively and quantitatively. The patient who vomits not only loses fluids from the body but also does not receive fluids which are the daily body requirement for the elimination of waste and regulation of body temperature. Under normal circumstances the average individual requires from 2,000 to 3,000 cc. of water daily for the purposes of elimination and temperature regulation. In addition to the fluid lost through vomiting a considerable amount of fluid may be immobilized in the non-absorbing portion of the intestinal canal which, because of distention and vascular damage, may be non-functioning. Thus the total water requirement may vary between 3,000 and 5,000 cc. when the patient is first seen.

The loss of salts varies with the amount

excretion may remove less than 5 Gm. in twenty-four hours. When the blood value for sodium chloride drops from the average of 650 mg. to the critical level of 520 mg., chloride secretion in the urine may drop to 0. Thus at least 5 Gm. of sodium chloride is necessary to maintain the blood chloride level. Gastric juice has approximately 4 Gm. of chloride in 1,000 cc. The amount of salt to be administered to the patient must include the daily normal requirement plus the amount lost through vomiting and the amount immobilized in the lumen of the intestinal canal. These amounts vary in different patients. It is unfortunate that a blood chloride determination does not always aid in establishing the degree of chloride loss. Table 1 indicates normal values in the blood. Profound changes in the blood resulting from hypohydration, etc., may be determined by the use of a few laboratory tests. However, early in obstruction the tendency for homeostasis to maintain normal values in the blood in

spite of tissue depletion makes such determinations of less value than a clinical estimate of the patient's condition.

A guide to the amount of fluid necessary to restore the fluid balance is the quantity of urine secreted. Since water for evapora-

depends on the patient's requirements. The patient is in need of sodium chloride but the quantity of this mineral must be administered in proportion to the patient's needs. It may be noted (Table 11) that 4,000 cc. of isotonic salt solution contains

TABLE I

	Plasma	Cells	Whole Blood	Blood Serum	
NaCl.....	650	...	.....	Dextrose	80-120 mg.
Na.....	340	0	160	Proteins	6.7-7.6 Gm.
Cl.....	370	190	250	Fibrinogen	0.27
K.....	20	420	200	Serum globulin	2.7 (1.5-3)
Ca.....	10	0	5	Serum albumin	4.1 (3.8-6)
P.....	...	...	3	Ratio:A:G	1.5:1-2:1
Mg.....	2.7	6	4	Hb	13 -15 Gm.
Fe.....	0.1	100	45	RBC	4.5-5.0 million
Cu.....	...	...	0.1	Hematocrit Male	42-48
Iodine.....	...	...	0.01	Female	39-45
CO <sub>2</sub> : (HCO <sub>3</sub> ).....	1:20	...	.....	S.G. Blood	1.057
pH.....	7.45	...	.....	Serum	1.025

tion to regulate body temperature has a priority, a scant income will show a diminished urinary output. The patient should be supplied with that quantity of fluid which will afford the elimination of 1,000 to 1,500 cc. of urine with a specific gravity that varies between 1.010 and 1.020. It is necessary to record the urinary output and keep a record of the volume injected since the administration of too much fluid may waterlog the patient. It has been found desirable to administer 3,000 cc. of fluid intravenously at the rate of one drop per second by continuous infusion over a twelve-hour period. To supply as much as 6,000 cc. when this amount is deemed necessary (*this is unusual*), it may be given at the rate of one drop per second over a period of twenty-four hours. A rapid administration of fluids to a hypohydrated patient increases the urinary output without hydrating the patient. The fluid passes from the blood stream into the kidneys and is eliminated with a very low specific gravity. This is a waste of fluids when hydration is desired although it may be desirable when toxins are to be eliminated.

36 Gm. of salt. This amount may be much more than is necessary for the patient and may be harmful in that the kidneys may not be able to eliminate the excess promptly enough. This will result in the

TABLE II  
INTRAVENOUS SOLUTIONS GM./1,000 CC.

	NaCl	Other Salts	Dextrose	Proteins
0.9% NaCl.....	9.0			
5.0% Dextrose.....	0.0	...	50	
5.0 Dextrose in 0.9% NaCl.....	9.0	...	50	
2.5% Dextrose in .45% NaCl.....	4.5	...	25	
Ringers Solution.....	8.6	.6		
Hartmans Solution.....	6.0	3.6		
Plasma.....	9.0	8.0	1	67.0
Amigen.....	2.0	...	50	50
Parcanamine.....	1.0	0.5	...	60
Aminosol.....	0.0	...	50	50
Whole Blood Citrated...	6.5	4.0	0.5	35

storage of salt in the body tissues, with the development of edema. If the patient already has renal damage, the ability to eliminate salt may be so impaired that edema will appear *more promptly*. One

should, therefore, gauge the amount of salt necessary by the volume of the vomitus plus the amount of secretion that may be removed from the intestinal canal by suction and the estimated amount of stagnant secretion in the intestinal lumen. Table 11 lists isotonic solutions which may be of value in intravenous therapy. The mixture 2.5 per cent dextrose with .425 per cent sodium chloride is a most desirable solution because its continuous administration will avoid the possibility of supplying too much or too little salt. It is an isotonic solution 4,000 cc. of which contain but 17 Gm. of sodium chloride. This amount frequently is an adequate amount in a twenty-four-hour period for the average individual with complete intestinal obstruction. In the absence of vomiting 4.5 to 9 Gm. of salt will suffice. The continuous use of .9 per cent sodium chloride with or without 5 per cent dextrose supplies too much salt. The use of 1,000 cc. of isotonic sodium chloride in distilled water or 250 cc. of 2 per cent sodium chloride as an initial dose helps to restore more promptly the immediate chloride and sodium shortage. The patient who is neither vomiting nor losing gastrointestinal secretions by suction or diarrhea is not in need of much salt. The use of 2.5 per cent dextrose in .45 per cent sodium chloride solution is safer since it avoids overmineralization when doubt exists as to the need for sodium chloride.

*Distention.* Distention of the abdomen in intestinal obstruction is caused by the accumulation of gas and the immobilization of fluids in the intestinal canal. The gas content represents for the most part (70 per cent) swallowed air. The remainder is derived from fermentation or putrefaction of intestinal contents and from the diffusion of gas from the blood stream into the lumen of the bowel. The immobilization of fluids in the intestinal canal is due to decreased peristalsis in complete obstruction, decreased absorption, venous stagnation and a continuous secretion due to secretagogue stimulation.

The results of distention are: (1) portal stagnation; (2) changes in the mucous membrane; (3) toxemia; (4) peritonitis; (5) thoracic disturbances; and (6) a decrease in volume and increase in concentration of the circulating blood. Portal circulation is assisted by active intestinal motility. In complete obstruction with distention, a marked reduction in motility occurs. This decreases the volume of portal circulation. When peristalsis returns, the bacterial laden blood floods the liver and produces the changes which in the past have been responsible for the death of the patient following relief from the obstruction. Dragstedt has shown that *Corynebacterium botulinum* toxin is absorbed by the mucous membrane in an obstructed loop of bowel but it is not absorbed by the mucous membrane in the unobstructed bowel. The alteration in the selective absorption of the mucous membrane may account for the toxic symptoms which appear in this condition. In the presence of distention diffusion of toxins of non-bacterial origin through the intestinal wall occurs. It is thought that these toxins may be absorbed by the lymphatics and carried to the blood stream. The nature of the toxemia and the origin of the toxins independent of the alterations in the blood are as yet not fully understood. Peritonitis can occur as the result of perforation or seepage of bacteria through the wall of a distended loop of bowel. Thoracic disturbances accompany marked distention. Descent of the diaphragm is difficult and restricted and respiration, both thoracic and abdominal, is impaired. A varying degree of anoxemia results from the failure of complete pulmonary ventilation. The respiratory difficulty also occasions cardiac distress. A negative intrathoracic pressure is required for the unimpaired passage of blood from the vena cava into the heart. This decrease in blood volume flow to the heart further contributes to the anoxemia. In the elderly patient the thoracic disturbance resulting in pulmonary disease and anoxia is frequently the cause of death.

The reduction in blood volume and concentration of the circulating blood is associated with disturbances in regulation of the body temperature and also the peripheral circulation. Frequently they are responsible for misinterpretations of laboratory data.

In view of the results of distention it is obvious that the indication for the treatment of this phase of intestinal obstruction is decompression of the distended bowel. This may be accomplished by intubation and suction. The important contributions of Wangenstein and Johnson and the development of the Miller-Abbott tube and its modifications have made treatment of this phase of intestinal obstruction possible without resorting to immediate surgery. In some instances decompression by the internal method may be difficult or impossible and the establishment of an ileostomy or cecostomy may be in order. In some cases (incarcerated hernia) prompt surgery may overcome the distention. Inhalation of oxygen has been suggested for its value in the removal of nitrogen by diffusion into the blood stream. Its general salutary effect in sustaining an elderly patient should warrant its more frequent use.

*Strangulation.* The extent of vascular impairment plays a considerable role in the severity of the illness of the patient. When strangulation of the bowel occurs in the free peritoneal cavity, the symptoms are more severe than when a similar acute strangulation occurs in a hernial sac. As a result of strangulation, a loss of blood proteins into the lumen of the bowel and into the peritoneal cavity occurs. The bowel itself becomes congested and holds immobilized a volume of blood that is in proportion to the length of the involved segment. In most instances the venous return is occluded before arterial obstruction takes place. The amount of blood pumped into tissues whose veins are occluded may be considerable. This loss of blood from the circulatory system may result in shock and prove fatal. Peritonitis frequently accompanies strangulation and toxemia is often

the cause of the profound symptoms which may be present. In view of these effects of strangulation it is clear that the indication for therapy for this phase of intestinal obstruction alone are the restoration of blood proteins and blood volume by the use of blood transfusions and the removal of the dead bowel from the peritoneal cavity as promptly as the condition of the patient will permit. Frequently the removal of dead bowel is the essential treatment for shock and infection. The value of hemotherapy, serotherapy and chemotherapy for their antitoxic or antibacterial effects must be kept in mind. The possibility of infection in any case is so likely that antibiotic therapy should be instituted early in the course of management.

#### SUMMARY

The duration of symptoms and the level of obstruction determine the intensity of three phases of intestinal obstruction from the point of view of preoperative therapy. The effects of vomiting may be overcome by the use of the appropriate quality of intravenous solutions in adequate amounts. Distention may be overcome by decompression through intubation and suction or if necessary, ileostomy, cecostomy or release of incarceration. The effects of strangulation may be overcome by the removal of the dead bowel from the peritoneal cavity as promptly as circumstances permit and by the use of blood or plasma transfusions.

While the patient is being prepared for a prospective operation, certain diagnostic and additional therapeutic procedures may be carried out. A complete examination is essential to observe hernias, scars, rectal tumors, etc. The patient's stomach is aspirated of its contents and washed out. A suction tube is inserted, continuous suction is instituted and a record is kept of the volume of secretion aspirated. In the absence of acute abdominal inflammation a 2-quart enema is given to empty the colon. A scout film of the abdomen is taken

to determine the bowel pattern. If distention decreases, suction is discontinued at intervals and 2 to 4 ounces of mineral oil are placed in the stomach. This oil is looked for in the subsequent washings from the large bowel. If only a small amount of the enema can be retained, a barium enema may be given and the site of obstruction noted on fluoroscopic examination or in the x-ray film. If repeated enemas fail to relieve the obstruction in the large bowel, a cecostomy is necessary to overcome the closed loop obstruction. When oil given by mouth fails to appear in the washings from the colon and the intestinal sounds disappear, complete obstruction of the small intestine is present and exploration of the abdomen is necessary. The presence of oil or gas in the washings from the colon indi-

cates that the obstruction is not complete or that the obstruction is relieved and urgency for surgical treatment is not essential. Obstruction low in the ileum is usually not associated with tenderness in the abdomen. In the absence of infection tenderness indicates vascular impairment to the bowel and early operation is, therefore, essential.

#### CONCLUSIONS

Of diagnostic and therapeutic value are the administration of parenteral fluids in adequate quantity and appropriate quality, intestinal decompression, enemas and the use of mineral oil by mouth. These measures constitute the important conservative and also preoperative therapeutic procedures in intestinal obstruction.



RESIDUAL stones in the biliary tract, pancreatitis, strictures or angulations of the ducts and hepatitis are some of the more common causes of the postcholecystectomy syndrome. A recent authority, however, discovered this syndrome in many patients in whom the only obvious disorder on re-operation was failure of the first surgeon to remove the cystic duct completely. It behooves us, therefore, to take a few more minutes time to do a complete cholecystectomy, making sure to remove the whole of the gallbladder and its duct. (*Richard A. Leonardo, M.D.*)

# EXTRAPERITONEAL CESAREAN SECTION

## A NEW PARAVESICAL APPROACH

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THE number of approaches to the retrovesical, intraperitoneal space utilized by advocates of extraperitoneal cesarean section has greatly increased. The author would like to present one which he prefers because of its simplicity, ease and rapidity of execution with fewer dangers. The approach resembles the Latzko paravesical approach but it is simpler.

### TECHNIC

Most men performing cesarean section by the extraperitoneal method advocate distending the bladder with 200 cc. of tinted fluid. The writer is much opposed to this practice since it prolongs the operative time, exposes the bladder to injury and distorts the anatomy. The bladder is exposed by a midline incision. It is unnecessary to incise the anterior sheath of the left rectus muscle which is separated from its bed down to the pubic bone. It must not be retracted so far laterally as to expose or injure the left deep epigastric vessels. The space of Retzius is opened by blunt dissection and the index finger is swept over the left anterior surface of the bladder until the left paravesical space is reached. It is not necessary nor is it advisable to incise the anterior vesical fascia as is frequently advocated. The "chicken yellow" fat area in the left paravesical space is identified. (Fig. 1.) This fat is swept aside with gauze held in a sponge-stick holder until the left lateral umbilical ligament is visualized. This is the medial boundary of the paravesical space and the lateral boundary of the bladder. It can be readily identified as a fairly thick ( $\frac{1}{8}$  to  $\frac{1}{4}$  inch) whitish ligament, on the surface of which course the vessels which supply it. (Figs.

2 and 3.) A retractor is placed lateral to this ligament and traction is made medially and inferiorly. This maneuver separates the ligament and the posterior surface of the bladder from the lower uterine segment. At this point the hernia-like tongue of peritoneum becomes visible superiorly (dotted line in Fig. 4). This tongue-like fold courses downward and mesially and can be followed throughout its course. By inserting the fingers beneath the separating bladder, the bladder can be further pushed medially (to the right) and inferiorly until a large enough space is obtained through which a baby can be delivered without difficulty. Up to this point no incisions have been made; all dissection has been bloodless and blunt. The exposed lower uterine segment must now be incised in a transverse crescentic fashion, concavity downward, for a distance of 2 inches, rarely more. The fascia overlying this incision may or may not be incised separately. If it is, fascial flaps are produced much as one does with the peritoneum in the two-flap type of cervical cesarean section. The upper flap of fascia may be retracted upward to protect the peritoneal tongue of peritoneum and the lower flap retracted downward and medially to protect the bladder. The author does not believe that this fascial incision is necessary if the exposure is adequate, hence, he has tried to eliminate this step whenever possible. (Fig. 5.) All retractors are now removed. A hand is inserted into the opening in the lower uterine segment. The opening is gently dilated until the closed fist can be admitted and withdrawn with ease. There is no danger of extension of the incision into dangerous zones if this is done gently. The baby is delivered by version and

breech extraction in vertex cases, forceps being avoided if at all possible (less than 2 per cent). It is my belief that forceps are

version and breech extraction but in extra-peritoneal sections the fetal abdomen should face the mother's head until the

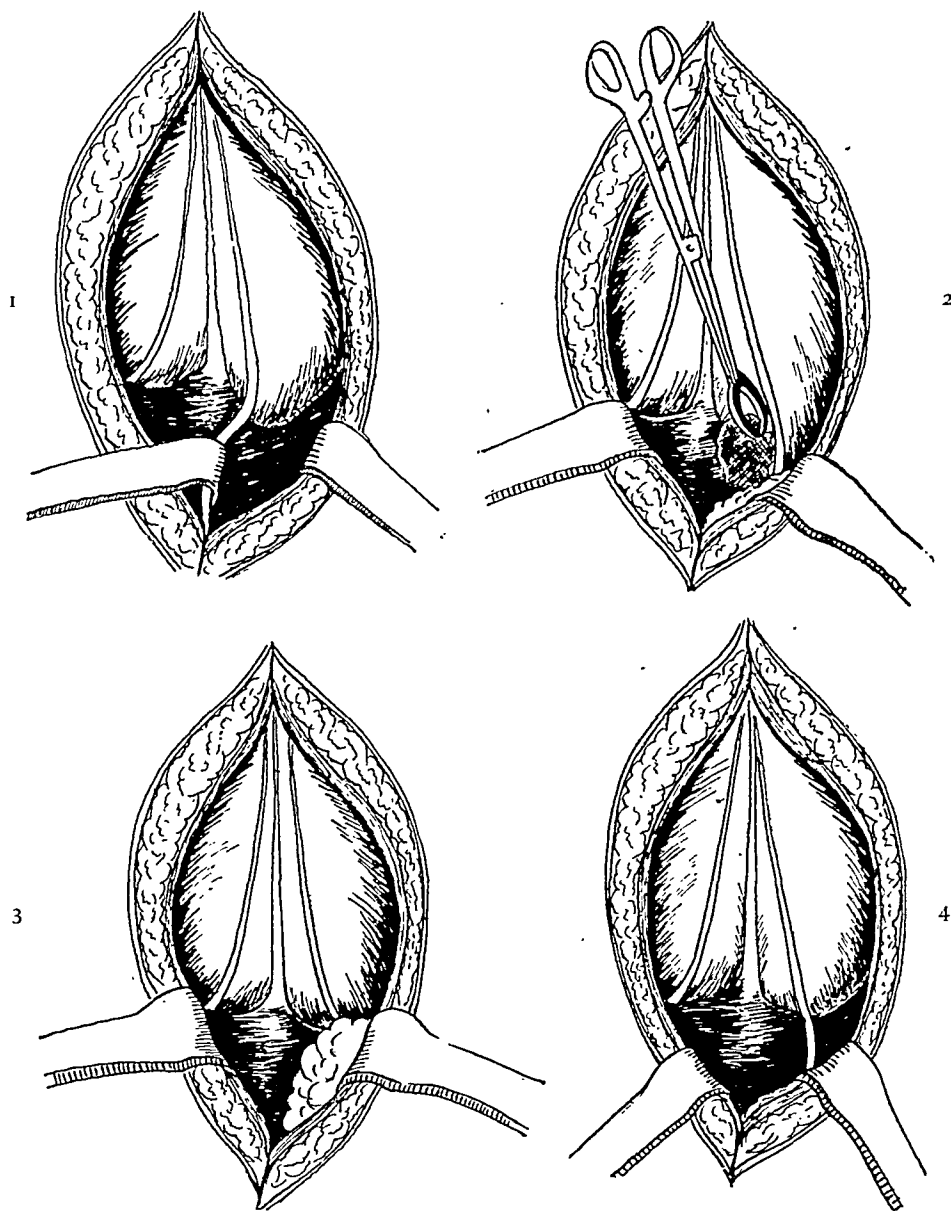


FIG. 1. Shows the medial and the two lateral umbilical ligaments. The chicken yellow fat is shown in the left paravesical area.

FIG. 2. The "chicken yellow" fat is swept aside by a sponge on a sponge stick holder exposing the left lateral umbilical ligament.

FIG. 3. The left lateral umbilical ligament and bladder are shown in early stage of separation. Note the triangular area of the low uterine segment. The peritoneum is shown as a dotted line.

FIG. 4. The bladder and left lateral umbilical ligament has been pushed further medially and inferiorly exposing a large area of the lower uterine segment.

responsible for many of the bladder and peritoneal injuries and extended tears that are reported. The fetus is delivered by

shoulders are delivered, at which time the fetus is rotated so that its back faces the maternal head. This makes delivery of the

after coming head easier. Oxytocics are given and the placenta is removed. The uterine incision is closed with two layers of chromic No. 1 and a third layer imbricates the lower uterine segment fascia over the wound. Drainage is avoided.

A comparison of the results obtained by the author in ninety-three cases in which his extraperitoneal technic was used with results obtained in fifty cases of two flap cesarean section also done by the author is shown in Table 1.

TABLE 1

Type of Section	No.	Operative Time (min.)	Hospital Stay (day)	Morbidity, Per Cent	Distention, No. of Cases	Bladder Symptoms, No. of Cases
Cervical cesarean.	50	24	10.5	8	6	3
Author's extra-peritoneal.....	93	22	8.5	none	none	none

The writer has followed the technic previously described in ninety-three cases. The peritoneum was injured four times, once in the only patient requiring forceps. There were no bladder injuries. All babies were born alive but five died within three days. Three fetal deaths were due to prematurity following cesarean section for placenta previa. One was due to congenital atelectasis at term and another followed abruptio placenta at eight months. There were no maternal deaths. No patient was morbid after the first twenty-four hours except one who had a two-day temperature and was diagnosed as having acute bronchitis on admission to the hospital.

## CONCLUSIONS

The writer presents for consideration a technic which he developed for performing extraperitoneal cesarean section which he

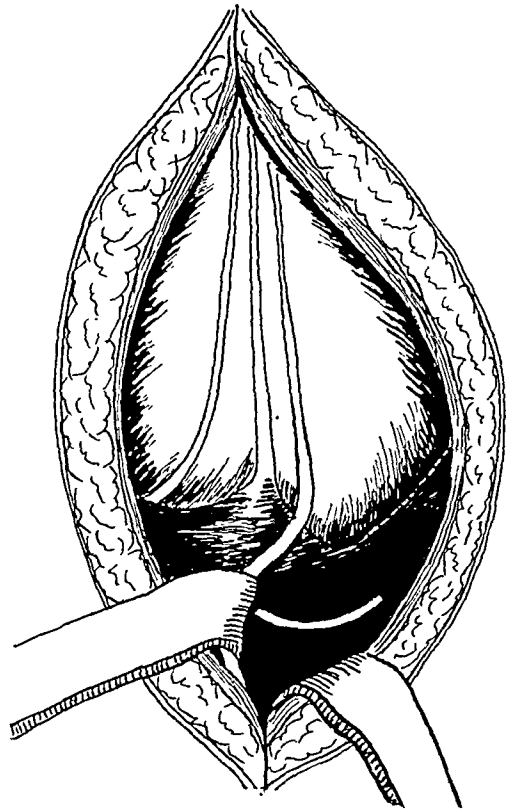


FIG. 5. A crescentic incision rarely more than 2 inches is made in the lower uterine segment through which the baby is delivered by version and breach extraction.

believes is simple to perform, rapid to execute, free from many of the dangers of the other types of extraperitoneal cesarean section and can be utilized as the cesarean section of choice in many cases.





# GELATIN SOLUTION AS A PLASMA SUBSTITUTE IN THE TREATMENT OF SHOCK FROM ACUTE BLOOD LOSS\*

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THE rapid growth of blood banks in this country and a survey of the extensive recent literature emphasize the value of rapid blood replacement in the treatment of hemorrhage. Experiences of the last war have borne this out. Reports from various maternal mortality committees reveal that an improvement in the control and treatment of hemorrhage offers the greatest opportunity for a further decline in the maternal death rate. "Hemorrhage is still the principal cause of maternal death."<sup>1</sup>

Nevertheless there is frequently a delay in instituting blood transfusion even in most urgent cases. Lack of available blood, typing, cross-matching and determining the Rh consume variable amounts of precious time. Although in some institutions blood is available for transfusion within five minutes, there are places and occasions where the time lag may be one, two or more hours. In these instances there is a great and urgent need for an injection fluid that can be satisfactorily employed as a temporary substitute for blood, particularly in cases of hemorrhage. The circulating fluid volume must be restored and maintained until blood itself is available. The exact time when shock or impending shock passes into irreversible shock is not known; although Wiggers and Ingraham<sup>2</sup> have shown in dogs that it occurred in the last fifteen minutes of a ninety-minute period of hypotension.

During and since the recent war pooled human blood plasma has been extensively used in the emergency treatment of hemorrhage and has been considered satisfactory from the point of view of availability and

effectiveness. Since pooling of plasma reduces the isohemagglutinin titer, blood grouping and cross-matching are unnecessary. Dried blood plasma can be stored without refrigeration and is quickly available when needed. Blood volume is effectively restored at least until blood itself can be given. Human blood plasma or any other substitute cannot replace the missing oxygen-carrying erythrocytes, but rather dilutes this oxygen-carrying capacity. Only blood can replace blood.

At the present time, however, the use of pooled human plasma carries a considerable risk of transmitting to the recipient a dangerous infectious agent, a hepatitis-producing virus. A number of conclusive experimental studies have shown that human plasma and serum may harbor the responsible viral agent.<sup>3-6</sup> Homologous serum jaundice was frequent among soldiers during the war two to five months following plasma transfusions.<sup>7</sup> The release of war stocks of dried plasma for civilian use has increased the incidence of serum hepatitis.<sup>8,9</sup> Brightman and Korns<sup>10</sup> found a 4.5 per cent incidence, with twelve deaths, attributable to homologous serum jaundice in patients who had received plasma during a previous six-month period. The English investigators, Spurling, Shone and Vaughan,<sup>8</sup> indicate a higher incidence of 7.3 per cent of homologous serum jaundice among 1,054 patients who had received pooled serum and plasma.

Blanchard and his co-workers<sup>11</sup> have demonstrated an effective method for irradiating icterogenic serum and plasma so that the hepatitis virus (SH) of homologous serum jaundice can be inactivated.

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But until this method has been accepted as effective and is in general use, pooled plasma should not be administered.

A 6 per cent gelatin solution of the macromolecular type appears to be an acceptable and, at the present writing, a superior substitute for pooled human plasma. It has been extensively investigated for this purpose.<sup>12-17</sup> The large molecules of gelatin have been shown to be the most effective for the control of blood volume, and a 6 per cent solution is hyperosmotic. The solution is compatible with the usual infusion fluids: glucose and physiologic saline solutions, whole blood, plasma, serum and amino acid solutions. The pH value and salt content are physiologically adjusted; the solution is sterile, free from pyrogens and apparently gives rise to no adverse reactions. If kept at 37°C., the gelatin is liquid and ready for immediate use, without necessity for typing or cross-matching. It quickly restores and maintains sufficient circulating fluid volume approximately up to forty-eight hours. The gelatin solution may be given as rapidly or slowly as indicated.

There are several disadvantages which can be overcome readily with simple precautions. The solution gels at room temperature so that it must be kept at a temperature above 29.6°C. in order for it to be available immediately for use. Liquefaction can be obtained quickly if necessary by dipping the infusion bottle in very hot water for ten minutes. After liquefaction the solution undergoes degradation so that it should not be used after one month. It may be stored indefinitely, however, at room temperature. Typing and cross-matching on gelatin-diluted blood is unreliable; sufficient blood should be drawn prior to the gelatin infusion, therefore, for present and future typings and cross-matchings.

Because of the renal effects and because of the hyperosmotic effects of the gelatin solution, its use should be avoided in patients with obvious renal damage or with cardiac impairment.

Since November, 1947, until February, 1949, ninety-seven patients were treated at the Kings County Hospital for shock or impending shock resulting from hemorrhage. The use of pooled human plasma was discontinued and a 6 per cent gelatin solution\* was used for all patients requiring intravenous therapy for shock from hemorrhage while awaiting the arrival of blood from the blood bank. The patients varied in age from sixteen to forty-eight years; fifty-four patients were colored.

#### METHOD AND MATERIALS

Following examination and emergency control of the bleeding, the patients were placed in Trendelenburg position and the blood pressure, pulse and hemoglobin were determined, as was a catheterized urine specimen. An intravenous needle was then inserted into any available vein, often the femoral vein, and blood was drawn for examination, typing, cross-matching and Rh determination. Fifteen to twenty cc. of blood were the usual amounts obtained. The gelatin infusion bottle was removed from the incubator and made ready for insertion into the intravenous needle. The infusion bottle carton contains its own disposable tubing and airway. The gelatin solution is permitted to run as rapidly as deemed necessary. A cold infusion bottle is used to replace the bottle removed from the incubator.

Blood pressures, pulse and general condition were observed at fifteen-minute intervals. As soon as the blood arrived from the blood bank, the gelatin tubing was disconnected and replaced by the blood. The gelatin bottle and the tubing were discarded.

Except in patients who continued to bleed, recovery from shock was awaited

TABLE I

	No.
Incomplete abortion.....	88
Ectopic pregnancy.....	4
Postpartum hemorrhage.....	4
Lacerated vagina.....	1

\* Gelatin Solution-Winthrop was generously supplied by the Winthrop Chemical Co.

before surgical treatment was attempted. The diagnoses of the ninety-seven patients are shown in Table 1.

As shown in Table II only six or slightly more than 6 per cent of the patients failed to improve within the first fifteen minutes.

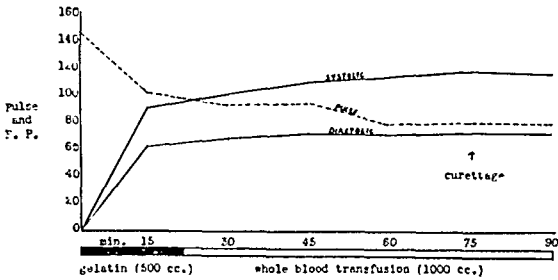


FIG. 1. M. K. Rapid response of blood pressure and pulse with gelatin solution and whole blood transfusion.

menstrual period was fourteen weeks prior to admission. The patient thought she was pregnant.

Examination revealed a patient in severe shock: cold, clammy skin, restless, extremely pale and bordering on unconsciousness. Large

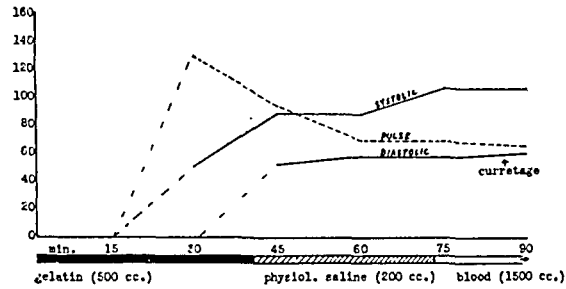


FIG. 2. Continued effect of intravenous gelatin solution after cessation of its administration. Blood transfusion had been unavoidably delayed.

All the patients, however, showed definite improvement at the end of thirty minutes and marked improvement at forty-five minutes.

TABLE II  
SUMMARY OF RESULTS

	15 Minutes	30 Minutes	45 Minutes
Not improved.....	6	0	0
Slightly improved.....	11	8	1
Moderately improved....	63	9	5
Markedly improved.....	17	80	91

There was no mortality in the entire series. All the patients received a whole blood transfusion following the gelatin infusion and were subsequently treated for the cause of the bleeding.

One patient in the series was admitted twice in shock and treated with the 6 per cent gelatin infusion at each admission, followed by blood transfusions. The admissions were five months apart both times for incomplete abortion. She had no reactions either from the gelatin or the blood.

CASE REPORT

M. K. White, aged thirty-one years, para viii, gravida xi, was admitted in severe shock, with a history of marked vaginal bleeding and clots of seven hours' duration. Her last normal

blood clots were removed from the vagina; the cervix was 3 cm. dilated and contained placental tissue which was removed. The uterus was the size of an eight weeks' gestation. Her temperature 96°F., pulse almost imperceptible and thready, about 140 to 150 per minute. The blood pressure could not be obtained. The patient's hemoglobin was 6.5 Gm., catheterized urine negative, about 10 cc. obtained. No obvious cardiac lesion was present.

A 6 per cent gelatin solution was started intravenously within five minutes after admission to the hospital. She received 500 cc. within twenty minutes. After fifteen minutes a blood pressure of 90/60 was obtained, and the pulse became stronger at 100 per minute. Whole blood was started at twenty minutes and the patient continued to improve, with full return of consciousness. The patient made a subsequent uneventful recovery, following a sponge forceps removal of the retained placental tissue. (Fig. 1.)

Figure 2 illustrates the continued effect of the intravenous gelatin after cessation of its administration. The patient's initial hemoglobin was 6.5 Gm.; no pulse or blood pressure was obtainable at the start of the infusion. The blood arrived seventy-five minutes after treatment was started.

No technical or mechanical difficulties were encountered. The warmed gelatin solution remained liquid throughout the period of the infusions and no special meas-

ures were taken to keep the solution warm during the injection. There was no plugging of needles. No anaphylactic or other reactions were noted in any of the patients although the effects of hemodilution were noted in those patients with a markedly lowered hemoglobin.

There were no deaths in the series. The gelatin solution proved effective within fifteen minutes in all but six patients, and these six, however, did respond well in the thirty-minute period. In eighty-five patients blood was ready and started within forty-five minutes. For the remaining twelve patients, however, there was a delay in the arrival of the blood from the bank up to 110 minutes despite a large and efficient blood bank. The value and effectiveness of the gelatin solution were here well illustrated. Eleven of these patients received physiologic saline solution following the gelatin, while awaiting the blood, and the blood pressure, pulse and general condition continued to improve in the interim. The remaining patient received a second infusion bottle of the 6 per cent gelatin solution, totalling 1,000 cc. of gelatin. No ill effects were observed.

Despite several reports of other investigators<sup>13,18</sup> none of the patients in this series developed venous thrombosis at the site of injection. From 500 to 2,000 cc. of whole blood were given following the gelatin infusions and in no instances did the transfusions have to be discontinued.

Most of the patients were in the younger age group. None of the cases revealed any cardiac or renal impairment or pulmonary edema. A marked diuresis was often observed following completion of the gelatin infusion. In sixty-nine of the patients an initial oliguria disappeared within fifteen to thirty minutes after the start of the gelatin infusion.

#### COMMENT

That gelatin solution has a hemodiluting effect when given intravenously has been demonstrated by several observers<sup>13,19</sup> as shown by plasma volume determinations.

September, 1949

Koop<sup>13</sup> has shown experimentally that replacement of two-thirds the volume of blood lost with a 6 per cent gelatin solution corrected the changes resulting from hemorrhage in the blood pressures, venous pressures, cardiac stroke volume and cardiac output.

While Koop found no demonstrable liver or kidney damage clinically, Skinsnes<sup>20</sup> demonstrated renal hydropic changes, similar to those produced by sucrose injections, in twenty-three patients who had died from other causes but who had received gelatin intravenously at varying intervals prior to their death. He thus had material for examination illustrating the changes that take place according to the time interval following the gelatin solution injection; and in this way, he states, he was able to determine that the renal changes are reversible. The renal hydropic changes were noted in the kidneys of those patients who had died one-half hour following the gelatin infusion and were not noted (and therefore assumed to have disappeared) in those patients who had died 120 hours after the last injection.

Approximately three to five days are required for the total excretion of the gelatin solution through the kidneys. At the end of the infusion 55 per cent of the gelatin remains in the blood stream, about 23 per cent is excreted during the infusion and 22 per cent is filtered into the tissues.<sup>19</sup>

Gelatin infusions should be avoided in patients with obvious renal damage since excretion is by way of the kidneys and a reversible pathologic change may possibly become irreversible. In patients with cardiac impairment the hyperosmotic effect of the gelatin solution (50 to 60 mm. of mercury measured across a standardized collodian membrane) may overburden the circulation and produce pulmonary edema.

#### SUMMARY AND CONCLUSIONS

1. Ninety-seven consecutive patients admitted to the receiving ward in varying degrees of shock from hemorrhage received a 6 per cent macromolecular gelatin solu-

tion intravenously while awaiting the cross-matching, typing, Rh determination and arrival of whole blood for transfusion.

2. All the patients had a good response, 93.8 per cent within fifteen minutes of the start of the infusion, as evidenced by a definite and sustained elevation of blood pressures, improvement in the quality and slowing of the pulse and in general clinical recovery from shock. There were no deaths in the series.

3. There were no anaphylactic or pyrogenic reactions observed. Venous thrombosis at the site of injection did not occur and none of the patients exhibited cardiac or renal disturbances.

4. The 6 per cent gelatin solution was found to be clinically effective and innocuous in the treatment of shock from acute blood loss. At present it is superior to the use of pooled human blood plasma because it eliminates the very real danger of transmission of the virus of homologous serum jaundice.

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# ANATOMIC CONSIDERATIONS IN THE TREATMENT OF CARPAL NAVICULAR FRACTURES\*

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**F**RACTURE of the carpal navicular is still a problem burdened by many complications such as delayed or non-union, aseptic necrosis and arthritis. Recently the complexion of this problem has been brightened by reports of successful treatment in several series of cases.<sup>8,9</sup>

The position of immobilization which is considered most satisfactory is not universally agreed upon. Some authors believe that the position of the immobilized extremity is immaterial as long as immobilization is applied early and prolonged<sup>6</sup>; some utilize dorsiflexion of the wrist with radial deviation<sup>11</sup> while others approve of dorsiflexion with ulna adduction.<sup>2</sup> The dorsiflexion recommended is slight, moderate or complete.<sup>4,10</sup>

In this study some aspects of this problem were investigated using anatomic and living material. The joints contributing to the movements of dorsiflexion and volar flexion also were studied as an integral part of the problem. It is realized that the conclusions of cadaver studies do not coincide with phenomena observed in the living, yet certain facts were demonstrated.

Three methods were employed to secure information about the mechanics of flexion and extension of the wrist. First, pins were inserted into the capitate and navicular, care being taken to disturb as little as possible the supporting soft tissues. Roentgenograms were taken in different attitudes of flexion and extension and the contribution to motion of the mid-carpal and radiocarpal joints measured. Second, specimens were dissected and the motion in these joints observed from different vantage points. Last, the wrists of live subjects were studied by roentgenograms and the

source of motion determined by noting changes in the axial relationships of the capitate, navicular and lunate.

When the wrist was placed in the neutral position and gradually flexed palmarward, motion occurred predominantly in the radiocarpal joint but the mid-carpal joint soon took over a great part of the motion as the flexion increased. When the hand approached 30 degrees of flexion, the radiocarpal motion diminished and the major amount of motion beyond 40 degrees of flexion arose from the mid-carpal joint.

When the hand was dorsiflexed from the neutral position, motion at first originated predominantly from the radiocarpal joint although the mid-carpal joint also participated. As the 30 degree mark was passed, the mid-carpal motion increased. Finally, when the radiocarpal joint locked, forcible further dorsiflexion produced a few more degrees from the mid-carpal joint. These findings agree generally with studies by Wright and others.<sup>12,7,5,3</sup>

The precise number of degrees originating from each joint in each change of position is intentionally omitted because of the variations in different specimens. The plan, however, is constant. In the middle range the radiocarpal joint moved predominantly. Marked flexion was due to mid-carpal motion. Extension resulted for the most part from radiocarpal motion but the final few degrees, when forced, was mid-carpal in origin. (Figs. 1 to 6.)

The navicular was fractured with an osteotome through a small lateral incision. Fractures were made transversely and obliquely at the proximal pole, waist and near the distal pole. These specimens were studied under fluoroscopy, by insertion of

\* From the Department of Orthopedic Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pa.

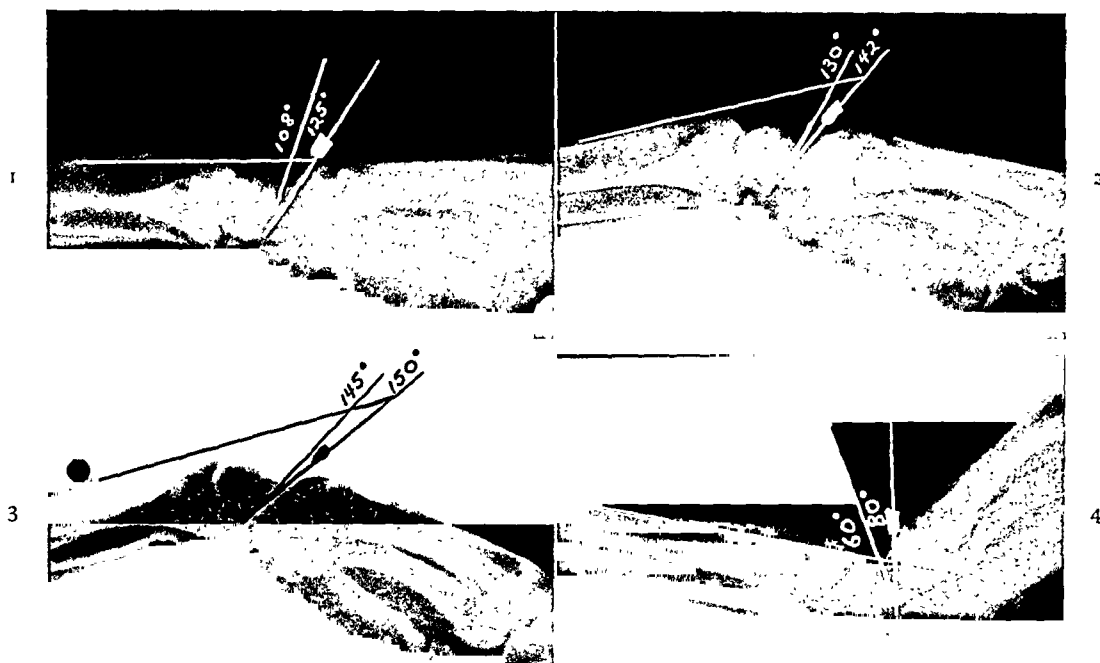


FIG. 1. The specimen is in the neutral position. The pin with the indicator is in the navicular, the other in the capitate. From this original position the angular change of each pin can be determined with the hand in various positions of palmar dorsiflexion. The pins have been darkened.

FIG. 2. The specimen is in 25 degrees of palmar flexion. The radiocarpal joint (navicular pin) contributed 17 degrees (from 125 to 142 degrees). The capitate pin traveled 17 degrees due to radiocarpal motion plus 5 degrees from mid-carpal joint motion (108 to 130 degrees).

FIG. 3. Palmar flexion is now 40 degrees. The radiocarpal joint (navicular pin) has given 8 degrees since Figure 2 (142 to 150 degrees). The capitate pin traveled 8 degrees due to radiocarpal motion and in addition added 7 degrees of mid-carpal motion (130 to 145 degrees).

FIG. 4. The specimen is now in 50 degrees of dorsiflexion. Referring to Figure 1 it is noted that almost all of the change occurred in the radiocarpal joint. The navicular pin traveled 45 degrees (125 to 80 degrees). The capitate pin added 3 more degrees from the mid-carpal joint (108 to 60 degrees).



FIG. 5



FIG. 6

FIG. 5. Dorsiflexion is now 80 degrees. All of the change arose from the radiocarpal joint.

FIG. 6. An anteroposterior view showing the insertion of the pins in the navicular and the capitate. The foregoing illustrations demonstrate the contribution of the radiocarpal and mid-carpal joints in flexion and extension of the carpus.

pins followed by roentgenograms and under direct observation. In all such fractures ulnar adduction of the wrist separated the fragments widely. Radial deviation brought them carpal into proximity; the distal row moving radially carried the multangulars into contact with the distal fragment and impacted it against the proximal fragment. The position of the thumb with the wrist in radial deviation did not appear to influence the fractured fragments. The distal carpal row acted as a single unit. Consequently, change of position of the thumb transmitted no effect through the well secured multangulars.

With the wrist in palmar flexion the fracture line gaped. Dorsiflexing slowly, it was noted that the fractured fragments began to approximate as the neutral position was approached and the motion was transferred from the mid-carpal to the radiocarpal joint. The distal row was then relatively fixed to the proximal row. This fixation forced the distal navicular fragment against the proximal as further motion originated predominantly from the radiocarpal joint.

At 30 degrees of dorsiflexion the fracture was a fine line. Continued extension to the point where the navicular had expended its motion caused further compression of the fragments. The navicular, held tautly proximally, was tightly squeezed by the capitate and the immobile distal carpal row mass. Such pressure was transmitted through the fracture site and the fracture line, which in palmar flexion gaped, was tightly gripped and could not be pried open.

Berlin advocated immobilizing these fractures in 45 degrees of dorsiflexion.<sup>1</sup> Even further dorsiflexion would be of greater advantage. He mentions the danger of carrying the distal fragment along

with the distal carpal row to override the proximal fragment if dorsiflexion is carried too far. These experiments indicated this occurred only in extreme forced hyperextension.

#### CONCLUSIONS

To secure firm apposition to the fractured fragments is a well recognized fundamental of fracture therapy. These studies indicate that this condition is not fulfilled in carpal navicular fractures until the wrist is dorsiflexed at least 30 degrees and that further dorsiflexion impacts the fragments. Radial deviation assists in securing closure of the fracture line. The position of the thumb did not influence the position of the fragments.

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## EPISACROILIAC LIPOMAS

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**E**PISACROILIAC lipomas often might be the cause of back pain which can be overlooked easily. Because of this patients are often subjected to prolonged pain, needless radiography and, at times, unnecessary surgery without relief of the symptoms.

Patients seek consultation because of back pain. This aching is usually of long duration. On examination of such a patient possible pelvic disease must be ruled out and urinary tract disorders kept in mind as well as possible hemorrhoidal and coccygeal complications. Flat feet can cause pain rather frequently. The numerous strains and sprains that result from previous injuries along with the various spinal conditions should be ruled out. Numerous systemic diseases may produce a backache or back weakness which the patient may describe as a dull ache.

If on general physical examination the aforementioned more common possible conditions have been ruled out and small tumors can be palpated in the vicinity of the sacroiliac joint which elicit exquisite pain upon pressure, episacroiliac lipomas must be considered as the cause of the pain.

The pain in the back is referred chiefly to the lumbar or pelvic regions. This pain often radiates down the front or back of the thigh; it usually does not go below the knee. This suggests pressure on the obturator or along branches of the genitocrural rather than sciatic nerves. At times there may be some limping. This pain does not seem aggravated by work but often occurs when the patient is sitting or turns in bed. Patients describe it as an ache. This complaint is usually present over a period of years rather than months.

Examination discloses a small, elastic, rubbery mass, very tender and freely movable,

near the sacroiliac joint. Such nodules are usually situated deeply against the bone. Pressure and manipulation not only elicit pain but cause pain to radiate in different directions. There are usually one or two nodules within 1 or 2 inches of the sacroiliac joint. They vary in size from a pea to the size of a walnut. These are found much more frequently in the female than the male and occur bilaterally more than unilaterally. At times only one of the two tumors is painful.

These lipomas are rounded, cylindrical bodies which measure from 1 to 5 cm. in diameter and 1 cm. in thickness. They are usually similar in size bilaterally but at times one may be larger. Microscopically, they consist of fat tissue with very little connective tissue between the fat cells and capsule of denser fibrous tissue. Nerve fibers are present in some.

If the cause of the pain is due to these lipomas, the injection of 1 per cent novocain gives relief. Therefore, this test may prove of diagnostic value. In the surgical treatment a transverse incision is used, usually under local anesthesia. The tumors are enucleated and the dead space is filled in by deep dermal tension sutures. The patient is usually hospitalized for one or two days.

### COMMENT

In our series of fifty cases there were thirty-six females and fourteen males. The oldest patient was sixty-one years of age and the youngest twenty-four. The average age was thirty-five. In thirty-five patients the pain was bilateral; in fifteen pain was unilateral. The longest duration of symptoms was seven years and the shortest two months. The average length of duration was eighteen months. In the matter of

anesthesia  $\frac{1}{2}$  per cent novocain was used in twenty-nine cases, cyclopropane was used in fourteen cases and sodium pentothal in seven cases. Relief from pain occurred in all but five in this series of fifty cases. In the five patients who continued to complain of the same pain two possibilities might have been the cause: one, an episacroiliac tumor was overlooked (this is especially likely to occur in obese pa-

tients); two, some other undetermined cause for the pain was present and was overlooked.

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# PELVIC FLEXION CAST IN TREATMENT OF CHRONIC LUMBAR BACKACHE

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**L**UMBAR backache is a condition which continues to disable many people seriously and which entails large economic losses. Although the etiologic factors are multiple, a frequent cause is simple breakdown of the supporting structures of the back due to excessive demand upon the part.

Everyone has a physiologic limit beyond which further stress or strain will result in symptoms of pain, spasm, aching, fatigue and limitation of function. This physiologic limit varies due to such factors as age, sex, muscular build, obesity and posture. Of these, one of the most important is posture. (Fig. 1.) Just how can poor posture result in a poorly functioning, painful low back? In 1924 Von Lachum published data showing that the pressure above the lumbosacral joint, tending to slide the fifth lumbar forward, varies with the angle of the sacrum.<sup>1</sup> The angle of the sacrum is proportional to the lumbosacral angle and, consequently, any increase in the angle of the sacrum results in a lessened lumbosacral angle\* and an increase in the lumbar lordosis.<sup>2</sup>

The lumbar curve is directly related to the thoracic curve so that an individual with increased lordosis must balance by increasing the thoracic curve, thus throwing the head forward in a stoop-shouldered position. Such an individual can remain compensated or free from pain until he encounters some unusual stress or strain as trauma, illness, obesity or changes incident to aging when the physiologic limit may

be reached resulting in the disabling symptoms associated with chronic lumbar backache.

The pelvic flexion cast first described by P. Haglund of Sweden and by Hauser of this country has proven a very effective means of restoring spinal balance by application of a corrective force.<sup>3</sup> Its advantages are multiple; it can be economically applied, does not require hospitalization of the patient and permits him to carry on with his work while wearing the cast. It is further possible for the patient to carry out limited postural corrective exercises while undergoing this treatment.

## PROCEDURE

The cast is usually applied with the patient flexed forward approximately 45 degrees, making every attempt to secure this flexion in the lumbar spine rather than at the hip joint. (Fig. 2.) The patient is supported by his extended arms against the back of a chair. It is applied over stockinet with felt over the iliac crests and anterior superior spines and a large piece over the spinous processes of the sacrum and posterior spine. The initial layers of plaster must be applied snugly and well molded over the iliac crests. Posteriorly, it must extend upward approximately to the thoracic sixth vertebra and downward well over the sacrum and buttocks. Anteriorly, the cast must be well placed over the anterior superior spines so that when finally trimmed it will be approximately 8 to 10 inches wide. It should be well reinforced posteriorly and trimmed. (Fig. 2.) Sufficient clearance should be allowed when trimming over the thighs so that the patient can sit in an ordinary chair without undue cast pressure. The stockinet may be

\* The angle of the sacrum is the angle formed by a line parallel to the superior articulating surface of the sacrum with the horizontal. The lumbosacral angle is the angle formed at the intersection of a line through the center of the body of the fifth lumbar vertebra with another through the center of the body of the sacrum.

cut and fastened over the edges with a final roll of plaster.

The cast may be worn for a period of four to eight weeks during which time trunk flexion and hip flexion exercises may be utilized. The cast occasionally seems to loosen during the first two weeks of wear-

lifting should be instructed in the proper use of the back so that further disability may be avoided.

#### CONCLUSION

The pelvic flexion cast is an efficient, economical means of correcting the cause

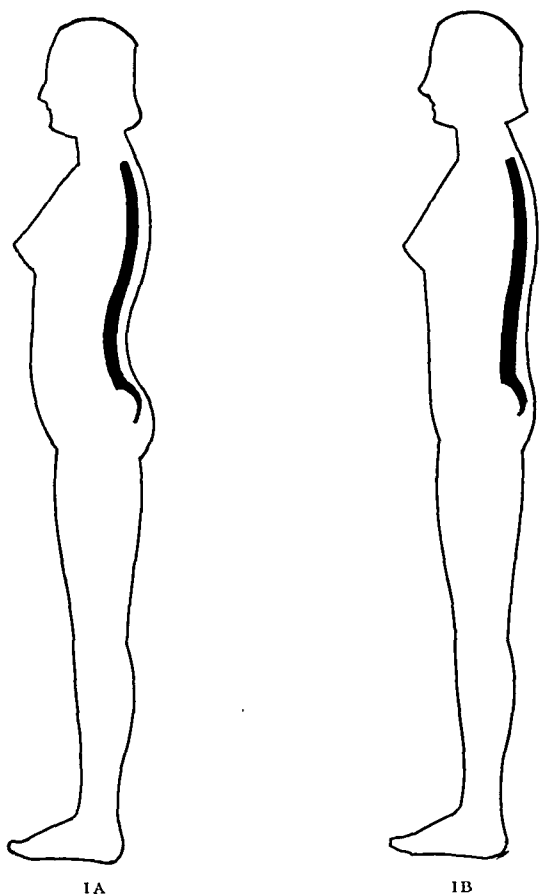


FIG. 1. A, poor posture with increased lumbar and thoracic curves and prominent abdomen; angle of sacrum is increased. B, normal erect posture with decreased angle of sacrum and consequent flattening of lumbar and thoracic curves.

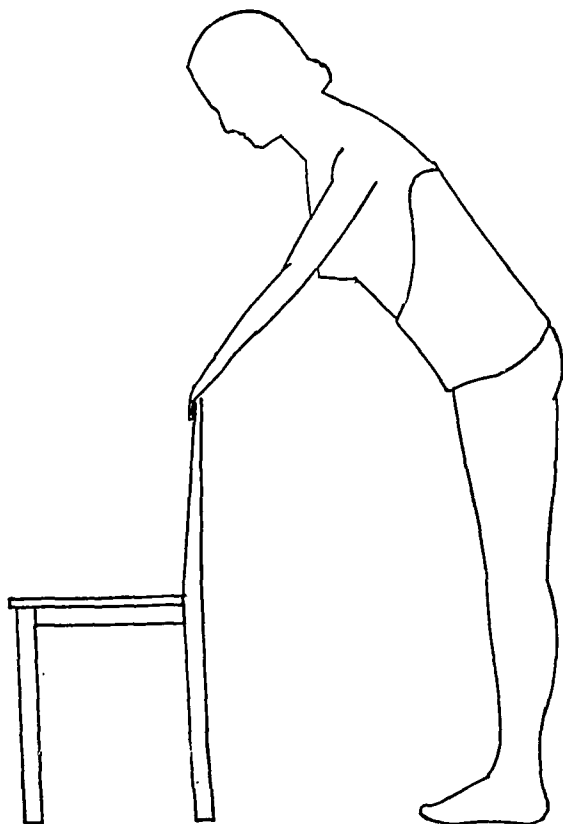


FIG. 2. Position of patient for application of flexion cast and appearance of cast after final trimming.

ing even though it was tightly applied. If this occurs, a new one should be put on. Ordinarily a new cast will be needed at the end of four weeks to obtain further pelvic flexion and flattening of the lumbar curve. This is particularly true in obese people and is probably due to the massaging effect of the cast upon the subcutaneous tissue, also indirectly by reducing caloric intake. When the cast is finally removed, a full program of postural exercises may be instituted. Laborers or persons doing heavy

of a large majority of chronic lumbar backache. The corrective force is in constant application whenever the patient is erect. It is easily applied and will give relief in a majority of cases if careful attention is given to the few details of application outlined herein.

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## CORNELL UNIVERSITY MEDICAL COLLEGE

CORNELL University Medical College was established by the Board of Trustees of Cornell University on April 14, 1898, when they elected Dr. William M. Polk Director of the College and Dean of the Medical Faculty, and appointed six professors. The medical college was made possible by the munificence of Colonel Oliver H. Payne who provided the funds for the erection of the original building of the medical college located at 28th Street and First Avenue and pledged his support to the new institution. For several years he provided funds for the annual support of the college and later placed the institution on a secure foundation by making generous provision for its permanent endowment by a gift of over four million dollars.

In October, 1898, instruction began in temporary quarters. As the medical college admitted a number of students to advanced standing, Cornell University granted the degree of Doctor of Medicine for the first time in 1899.

The Cornell University Medical College from its foundation has undertaken to carry out two allied activities, the development of physicians and the extension of medical knowledge by means of research. The medical faculty has held from the beginning of its existence the attitude that these two functions are necessary as constituting a true university school.

The Cornell University Medical College and the New York Hospital have been cooperating for a long time in an arrangement for medical teaching. In September, 1932, however, the two institutions took up occupancy in the same plant.

The New York Hospital was founded by Royal Charter on June 13, 1771 in the

reign of King George III and has stood throughout the life of the nation as one of the foremost hospitals in the United States, as an institution rendering service to the sick and injured and as a center of medical education. For a number of years the hospital and the medical college had been partially affiliated. In June, 1927, an agreement was entered into between Cornell University and the New York Hospital by which the New York Hospital-Cornell Medical College Association was formed for the purpose of bringing together their facilities and cooperating in the care of patients, in medical education and in medical research.

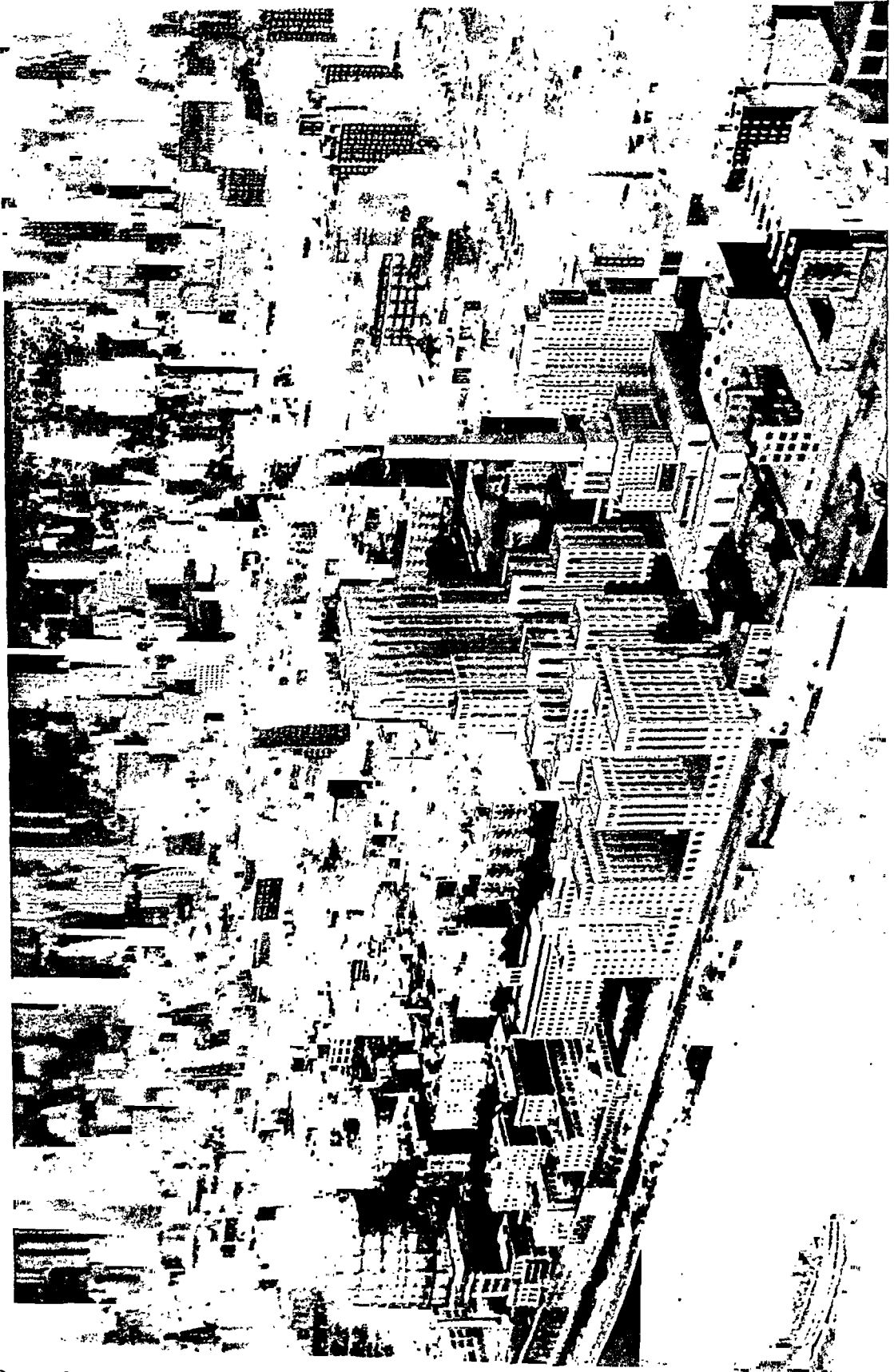
Additional endowment was secured by each institution. A group of buildings was erected along the East River between 68th and 71st Streets adjoining the Rockefeller Institute for Medical Research. The new plant affords separate buildings for each of the various laboratory departments and includes approximately 1,000 hospital beds. Provision is made for medicine, surgery, obstetrics and gynecology, pediatrics and psychiatry in five distinct clinical units.

The faculty of the medical college and the professional staff of the hospital are organized so as to form one body established on a university basis.

The new plant affords very favorable conditions for the conduct of medical education, for the pursuit of medical research and for the care of patients in all phases of medical practice.

The total endowment available to the Medical College for research and teaching amounts to approximately \$12,000,000.

The accompanying photograph of Cornell Medical College was supplied by William S. Ludd, M.D.



Cornell Medical College

September, 1949

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# Streamlined Articles

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## THROMBOEMBOLISM

### PROPHYLAXIS AND TREATMENT

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THROMBOEMBOLISM continues to hold its place as a major problem of treatment today in medicine and surgery. In the past ten years renewed interest has stimulated many groups to advocate different methods of therapy. The methods sponsored, often with ardent statements of their value, are early ambulation, anti-coagulants, vasodilation and proximal vein interruption. It is recognized that these methods have valid reasons for their use, prophylactically and in reparative therapy. However, a search of the literature fails to reveal any vigorous championing for or against a combination of all methods. It is the purpose of this paper to review the reasons for the use of these methods of treatment, and to propose a program of treatment which would combine the good features of all methods.

\* \* \* \*

Age, peripheral vascular disease, blood dyscrasia, carcinoma, cardiac diseases, obesity, paralytic ileus, dehydration, varicose veins and severe infection all have an influence on the development of thrombophlebitis. Duryee<sup>10</sup> states that thrombophlebitis occurs most frequently between the ages of fifty and seventy in men, between forty and sixty in women and more commonly in obese individuals of either sex in their age groups. Allen<sup>4</sup> has shown in a large series of cases at Massachusetts General Hospital that 82.3 per cent of thrombophlebitis occurred in patients over forty and that the peak incidence of 25.3 per cent occurred between forty and fifty.

Medical patients are affected as frequently as surgical patients. The incidence of thrombophlebitis in surgical patients is said to be 1 to 2 per cent.<sup>11</sup> Barker and his co-workers<sup>6</sup> point out the fact that 6 per cent of all cases of thrombophlebitis end fatally and that 25 per cent of clinical thrombophlebitis have pulmonary embolism.

The time of postoperative pulmonary embolism as shown by Morton, Mahoney and Mider<sup>21</sup> is principally within the first two weeks, 50 per cent in the first week, 30 per cent in the second week and 14 per cent in the third week. Thus 80 per cent of pulmonary emboli were seen to occur in the first two weeks following surgery. With these facts in view, the diagnosis, prophylaxis and treatment may be more easily instituted.

#### SIGNS, SYMPTOMS AND DIAGNOSIS

The clinical signs and symptoms which present themselves in thrombophlebitis are dependent on the degree of inflammatory reaction, the degree of thrombosis with occlusion and the individual reactions of the patient to the process.

Pain and tenderness, swelling, coldness, cyanosis of extremities, fever, chills, tachycardia, tachypnea, malaise, apprehension, elevated leukocyte count and elevated sedimentation rate are present in various proportions in most cases of thrombophlebitis. However, all of these signs and symptoms may be minimal or absent in an extensive process, so certain diagnostic methods should be used in all patients who are candidates for thrombophlebitis.

*Elicitation of Pain or Tenderness by Palpation.* The plantar veins should be palpated first, then the calf muscles, the popliteal veins and the course of the femoral veins including the region of the fossa ovale. Dorsiflexion of the foot for resultant calf pain (Homans' sign) is sometimes beneficial. The presence of these signs reveals thrombophlebitis of the deep circulation. Redness, induration and tenderness along the course of the superficial veins indicates involvement of the superficial venous system.

*Examination of the Extremities for Swelling and Evidence of Venous Occlusion.* Leg measurements 5 inches above and below the patella are the best index to early recognition of swelling. It is most important to record the initial measurements preoperatively in surgical patients and upon medical patients when first confined to bed. Meigs<sup>20</sup> considers an increase in size of more than 1 cm. significant. Pitting edema, coldness of the extremity and early cyanosis may be present. Arterial pulsations of the femoral, popliteal, dorsalis pedis and posterior tibials are palpated for reflex angiospasm. Dilatation of superficial veins is noted.

*Search for Constitutional Signs and Symptoms.* Fever, elevated pulse and increase in respirations are considered indicative. Chills, malaise and apprehension are significant. The leukocyte count with differential counts and sedimentation rates should be done at frequent intervals.

Signs and symptoms of pulmonary embolism vary as to the size, number and frequency of the emboli and as to the individual response to this phenomenon. Pleuritic or substernal chest pain is the most frequent symptom of a pulmonary embolus. Hemoptysis is sometimes seen. Dyspnea, tachycardia, fall in blood pressure, apprehension, sweating, weakness, pallor, fever, vomiting, cardiac arrhythmias, roentgen changes, suppressed breath sounds, splinted and high diaphragm, pleural friction rub, pleural effusion, complete collapse and sudden death are signs

and symptoms of pulmonary emboli. Many of these are the result of vasospasm and bronchial spasm from the lodgment of the embolus or emboli in the pulmonary artery or its branches.

#### EARLY AMBULATION

The practice of early ambulation as a prophylactic measure has been advocated for many years. Ochsner and DeBakey<sup>25</sup> stress that ambulation is used to decrease the circulatory retardation and to diminish the incidence of respiratory infection. Standing and walking within twenty-four to forty-eight hours following an operation is considered as the true meaning of early ambulation.

Hollenberg<sup>11</sup> states that ambulation after four or five days is more dangerous than very early rising or continued bed rest due to the fact that a thrombophlebitis usually begins to develop in the first few days of recumbancy and the danger of throwing off emboli is greater in this period.

Early rising is coupled with leg exercises, frequent changes in position, avoidance of tight abdominal binders, deep breathing, prevention of gastrointestinal or bladder distention, maintenance of fluid and electrolyte balance, prevention of infection, correction of anemia and sometimes the use of anticoagulants.<sup>26</sup>

Jorpes<sup>14</sup> shows that the incidence of postoperative thrombophlebitis can be reduced to as low as 0.6 per cent by postoperative exercises and early ambulation. Kirby<sup>15</sup> considers the two most important factors in 80 per cent of all pulmonary embolisms as: (1) the age of the patient is above forty and (2) the patient has been confined to bed by illness or operation. Early ambulation certainly eliminated the latter of these two factors.

#### VASODILATION

Sympathetic block has been advocated as an active measure of therapy in thrombophlebitis to relieve artdriolar spasm.<sup>24,25</sup> DeBakey, Burch and Ochsner<sup>9</sup> have described this reflex pathway. Thus by block-



ing these impulses and obtaining a release of the vasospasm there is relief of pain which is primarily a pain of ischemia. The edema decreases to the extent allowed by the mechanical plugging of the veins by increasing the blood flow through the arterioles relieving the anoxia and excessive capillary permeability. The spasm of venules is abolished also and allows for the absorption of edema fluid.

There are two methods of producing a sympathetic block. The older method is that of a paravertebral injection of the sympathetic ganglia with a local anesthetic agent. This is essentially a regional block and its value varies directly with the experience of the operator. Parenteral injection of tetra-ethyl-ammonium has been shown to produce a blockade of nerve impulses at the autonomic ganglia.<sup>1,2</sup> Parenteral TEA injections is an easy and practical method of obtaining a sympathetic block for the clinician and patient.<sup>7,28</sup>

#### ANTI-INFECTIVE AGENTS

The use of antibiotics and chemotherapeutic agents in the treatment of thromboembolism may be considered a supportive measure. Murray<sup>23</sup> states that in only 0.5 per cent of cases is infection a factor in the production of a thrombus. However, Morton and associates<sup>21</sup> found that infection was present in some part of the body in 75 per cent of patients with embolism. By this they refer to any type of bacterial invasion such as pneumonia, genitourinary tract infection, peritonitis, cellulitis, wound infection, gangrene, etc. Due primarily to Morton's figures we believe that the use of penicillin or a sulfa compound is beneficial in most cases of thromboembolism and thus advocate its use.

#### ANTICOAGULANTS

The anticoagulants in current use for prophylaxis and treatment of thromboembolism are heparin and Dicumarol. The methods of administration, length of action, ease of control, effectiveness of the

drug and expense of the substance govern somewhat the use of these two chemical components. Some of the advantages and disadvantages of these anticoagulant agents help determine the indications for their use.<sup>5</sup>

The advantages in the use of heparin are: (1) quick effect on blood (ten to fifteen minutes), (2) quick disappearance of effect on blood (two to three hours) and (3) it may be administered without laboratory control. The disadvantages are: (1) it is expensive (\$7.00 a day), (2) it is given by parenteral administration only and (3) it sometimes produces hemorrhagic complications at the site of injection and other points also.

The advantages of Dicumarol are: (1) it is inexpensive (only a few cents a day) and (2) it is effective orally. The disadvantages include: (1) the effect on the blood is delayed (twenty-four to seventy-two hours), (2) effect on the blood persists for days after cessation of administration (two to twelve days), (3) daily determinations of prothrombin time are necessary for efficient and safe administration and (4) it sometimes produces hemorrhagic complications. With these facts in mind, heparin and Dicumarol are considered separately and their clinical significance determined.

*Heparin.* The actions of heparin as described by Loewe, Rosenblatt and Hirsch<sup>17</sup> are: (1) it prevents the conversion of prothrombin to thrombin, with the aid of a plasma cofactor; (2) it forms with serum albumin a strong antithrombin and (3) it prevents the formation of thromboplastin from the platelets. Loewe<sup>18</sup> stresses the point that the multiple action of heparin on prothrombin, thrombin and thromboplastin may be explained as a loading and unloading of the electric charges on the various protein components, thus preventing the propagation of a clot regardless of its site or stage. It therefore explains the disappearance of the earliest stage of clot formation (sludge) under heparin therapy.

Heparin is available in 10 cc. vials containing 10 mg. per cc. diluent and is ad-

ministered parenterally. The intravenous administration is by continuous intravenous drip or by periodic injections. If given by the continuous drip the optimum coagulation time of thirty to forty-five minutes (Lee and White method) is considered desirable.<sup>3</sup> For continuous intravenous injection the method described by Lucia<sup>19</sup> is satisfactory. Intravenous injections of heparin may also be given every four hours in 50 mg. doses. Heparin acts within a few minutes and lasts only two and one-half to three hours, but the overall effect is equally as satisfactory. Coagulation times should be done just prior to each injection to determine the individual's variation to the drug. The coagulation time with this method should be kept near ten to fifteen minutes.

The use of heparin Pitkin menstruum as described by Loewe and his co-workers<sup>17</sup> has overcome these disadvantages and has been a very satisfactory addition to the methods of administration. One subcutaneous injection of 300 mg. of heparin in Pitkin's menstruum has been found to cause elevation of the coagulation time for approximately forty-eight hours. The span of treatment is usually ten to fourteen days. The patient is permitted ambulation when full heparinization is in effect. Following a pulmonary embolus an additional seven to twelve days of therapy is recommended.

Overdosage of heparin can be remedied by the use of protamine which can be given intravenously and acts by neutralizing heparin in approximately stoichmetric proportions. Kirby<sup>15</sup> stresses the importance of remembering that protamine is toxic in large amounts. Loewe, Rosenblatt and Hirsch<sup>17</sup> note that digitalis inhibits the anticoagulant action of heparin and advise the avoidance of the use of digitalis during heparinization if possible.

**Dicumarol.** The action of Dicumarol is relatively slow, usually taking twenty-four to forty-eight hours for maximum effect. It is administered until the patient is ambulatory for three to seven days. The effect of Dicumarol ordinarily continues

for two to twelve days after treatment is discontinued.

The dosage of Dicumarol must be based on the blood prothrombin value. Prothrombin values of 20 to 30 per cent of normal (twenty-seven to thirty-five seconds Quick method) are considered satisfactory. The dosages as suggested by Allen<sup>5</sup> are commonly used. Overdosage of Dicumarol is combatted by blood transfusion and intravenous vitamin K. Levan<sup>16</sup> points out that stored blood loses its prothrombin, and for beneficial effect blood less than twenty-four hours old should be used.

Hemorrhage is the only toxic effect of Dicumarol. Sixteen to 27 per cent of patients are said to be hyper-reactors to Dicumarol; however, Allen<sup>5</sup> reports 3.1 per cent in his series. Daily physical examination and urinalysis are indicated in all patients on anticoagulant therapy for this reason.

The simultaneous use of heparin and Dicumarol seems to be the most satisfactory method of anticoagulant therapy. Heparin intravenously or subcutaneously is started for the immediate effect and Dicumarol is given orally in full dosage. When the prothrombin level is sufficient, heparin is discontinued and the patient is controlled on Dicumarol alone.

Contraindications to anticoagulant therapy include renal insufficiency, hepatic damage, bacterial endocarditis, recent brain or cord injury and blood dyscrasias.

#### VEIN INTERRUPTION

The prevention of thrombosis and embolism by superficial femoral vein interruption was suggested by Homans<sup>12</sup> in 1934. Allen<sup>4</sup> in a controlled series of patients over sixty-five years of age reported 458 bilateral prophylactic superficial femoral vein interruptions. One patient who had had the vein divided developed a fatal embolus. Allen attributes this to faulty technic in that the vein was divided 3 cm. distal to the profunda femoris and at autopsy a firm thrombus was present in the proximal segment of the interrupted

vein. Five patients of this series of vein interruptions had a history of a subsequent mild thrombophlebitis. In a group of 458 patients without prophylactic vein interruptions there were fifty-five cases of thromboembolism and twenty-six of these were fatal. In a breakdown of the series there were 110 fractures of the hip in each group. In those with prophylactic vein interruptions there were two patients with thrombophlebitis and no fatalities, but in the non-interrupted vein group there were twenty cases of thrombophlebitis and eleven fatalities by embolism. Veal<sup>27</sup> in report of forty-nine patients with thigh amputations and prophylactic vein interruptions noted no deaths from pulmonary embolism but in a similar series without prophylactic vein interruption there were six patients who died of embolism. Allen<sup>4</sup> was impressed by the almost negligible symptoms following interruption of the normal superficial femoral vein. He states that this procedure is not expected to do more than lower the incidence of fatal emboli and act as an added dividend that thrombophlebitis is likewise prevented. The procedure should be performed at the time bed rest becomes necessary. If major surgery is contemplated, it has been suggested to withhold vein interruption until surgery is finished since bleeding is temporarily increased by femoral vein interruption.

The treatment of thrombophlebitis with and without embolic phenomena should include venous ligation and thrombectomy if possible. Allen<sup>4</sup> points out that it is better to ligate a normal vein and err on the side of action than lose a patient from a sudden embolus. Morton and associates<sup>21</sup> believe that there is too great a tendency of physicians and surgeons to feel secure once clinical thrombophlebitis is present in that there is little danger of pulmonary emboli. With evidence of pulmonary embolism Barker<sup>6</sup> showed there is 44 per cent chance of a second embolus and 18 per cent chance of a fatal embolus.

Allen<sup>4</sup> stated that as of October 1, 1946,

there had been 1,060 patients treated with femoral vein interruption for thrombophlebitis after signs and symptoms of thrombosis or infarct and there were no fatalities as result of the operation. He lists less than 5 per cent of these had subsequent infarcts and in most cases these were minor. He reports only five deaths, all had infarcts prior to femoral vein interruptions and all but one were well advanced in age with an incurable disease. He further states that if prophylactic femoral vein interruption had been performed these embolic fatalities would have been avoided.

The site of interruption is not always an easy problem. The veins are exposed best through a vertical incision and ligatures that are not tied are placed around the common femoral vein, superficial femoral vein and the profunda femoral vein. By manipulation of these ligatures after superficial femoral vein is opened, one can determine which vein is patent by presence of free flow of blood. The superficial femoral vein is opened transversely. If a clot protudes, it is gently removed from the proximal vein by forceps and suction. When free bleeding occurs proximally, one knows then that the common femoral and iliac veins are cleared. The clot is then sucked out of the distal portion of the superficial femoral vein. The ligatures are then tightened about the common femoral and the superficial femoral vein to determine the patency of the profunda femoral vein. If only the superficial femoral vein is involved, it is divided between ligatures just below the profunda and the ends are transfixed with a suture. If the superficial femoral and profunda are involved, the common femoral vein is then ligated just below the entrance of the saphenous vein. Occasionally the profunda is the only branch involved and it is interrupted at its junction with the common femoral vein. When the clot is firmly attached to the common femoral vein and extends up into the iliacs, it may be wiser to ligate the

inferior vena cava because of its easier approach than attempt to ligate the iliacs. Moses<sup>22</sup> has noted that following bilateral interruption of femoral vein, embolic phenomena continue and it is then apparent that the problem has not been solved. The emboli probably arise from the pelvic viscera, and Moses believes that an inferior vena cava ligation provides the most satisfactory solution. The right lumbar retroperitoneal approach is preferred for this procedure in males. In female patients and especially those without signs of thrombophlebitis of the lower limbs but those of a pelvic thrombophlebitis, Collins and associates<sup>8</sup> have advocated the trans-abdominal ligation of the inferior vena cava and the ovarian veins. Allen<sup>4</sup> believes that inferior vena cava ligation should be used for those only with obvious septic infarcts. Homans<sup>13</sup> advocates inferior vena cava ligation when thrombosis is present in the iliac veins because it means one less operation.

#### TREATMENT

The lack of agreement in the treatment of this problem is readily apparent. It is known that the use of any one of the previously mentioned methods has materially reduced the fatal results of this condition. However, since several factors are involved in the production of thromboembolism, a combination of all methods should be used in the treatment of the various stages of the disease.

The treatment of thromboembolism may be divided into the prophylactic and reparative phases. With a strict program of prophylaxis the incidence of thromboembolism should be quite small. This will reduce to a minimum the ligations of the inferior vena cava, common femoral vein, thrombectomies and severe postoperative edema and ulceration.

The prophylaxis may be instituted along the following lines: (1) All patients, medical bed and major surgical patients, over the age of forty should be treated with

Dicumarol immediately following surgery or at the beginning of bed rest. (2) Superficial femoral vein interruption is reserved for (1) medical bed and major surgical patients over forty in whom Dicumarol is contraindicated and (2) patients over sixty-five who must remain in bed or for whom major surgery is planned. (3) Early ambulation should be instituted as soon as feasible. This includes daily leg exercises while in bed. (4) Twice daily examinations of patient should be made for elicitation of pain or tenderness of limbs by palpation, edema or evidence of venous occlusion, and search for constitutional signs and symptoms.

The reparative therapy begins once there is clinical signs of a thrombophlebitis in the lower limbs or evidence of a pulmonary embolus. If the previously outlined program is followed, we expect this group of patients to be quite small. The treatment is as follows: (1) Exploration of the superficial femoral, profunda femoral and the common femoral veins should be done with interruption of the appropriate veins bilaterally. Thrombectomy is to be performed. If the attachment of the thrombus extends into the upper portion of the common femoral and/or iliac veins, a ligation of the inferior vena cava is indicated. With septic pulmonary emboli and following a negative exploration of the femoral system, the inferior vena cava should be ligated, and in female patients the ovarian veins should also be ligated. (2) Following vein interruption simultaneous heparin and Dicumarol therapy should be started three hours postoperatively. (3) Vasodilation measured, autonomic blockade with tetraethylammonium or paravertebral sympathetic blocks with a local anesthetic should be employed for several days to promote collateral circulation with a reduction of leg edema and relief of pain associated with vasospasm. (4) The appropriate antibiotic and chemotherapeutic agents are to be used. (5) Ambulation is begun as soon as the general condition permits.

## SUMMARY

1. The problem of thromboembolism has been briefly reviewed.
2. The rationale and general results of the treatment of thromboembolism by early ambulation, vasodilation, antiinfective agents, anticoagulants and vein interruption has been presented.
3. A program has been outlined for the prophylaxis of thromboembolism and the active treatment of thrombophlebitis and thromboembolism.

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# MALIGNANT LYMPHOMA OF THE STOMACH\*

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A CASE of malignant lymphoma, lymphoblastic, noncirculating type, involving the stomach is pre-

blastoma or large cell lymphosarcoma. The localized tumor represents a transient clinical phase of the disease<sup>3</sup> arising from

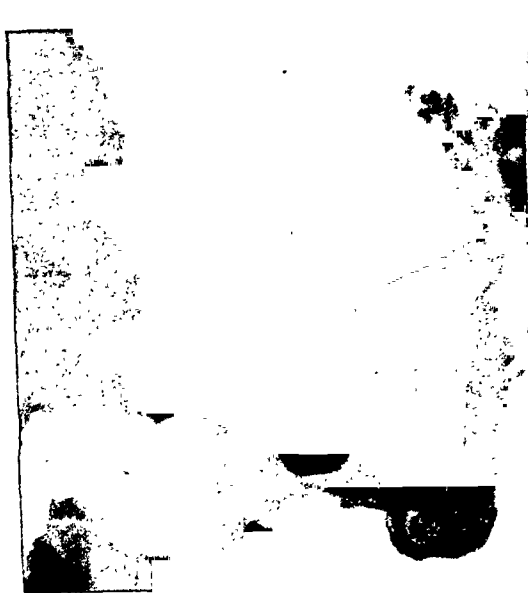


FIG. 1. Meniscus complex along lesser curvature of stomach.



FIG. 2. Gross specimen of the stomach showing the elliptical ulcer crater with smooth, rolled edges.

sented. Early surgical removal of such lesions usually offers a better prognosis than surgical treatment of any other neoplasm. The lack of response by this tumor to postoperative irradiation is in accord with the results noted by Gall and Mallory.

\* \* \* \*

Malignant lymphoma of the stomach is a rare disease; a review of the literature revealed 250 cases reported.<sup>1,6,7,13,15</sup> According to the classification of Gall and Mallory<sup>3</sup> this tumor was classified as above according to its cytology. By other authors this type would be referred to as lympho-

the lymphoid follicles of the submucosa of the stomach. The lesion occurs more frequently in the male and usually during the fourth decade.<sup>7,10,13</sup>

The tumor *per se* is seldom diagnosed preoperatively. The diagnostic procedures such as x-rays and gastroscopy reveal an ulcerated tumor of the stomach usually indistinguishable from carcinoma.

## TREATMENT

Therapy consists of radical surgery, irradiation or a combination of the two. In well localized lesions, radical surgical removal is the treatment of choice.<sup>1,4</sup> In

\* From the Departments of Surgery and Pathology, Veterans Administration Hospital, Des Moines, Iowa. Published with permission of the Chief Medical Director, Departments of Medicine and Surgery, Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the authors.

large inoperable tumors, roentgen therapy alone has resulted in five-year cures in certain cases.<sup>1</sup> Gall and Mallory<sup>3</sup> found in their series of 618 cases of malignant lymphomas that 21 per cent of the lymphoblastic type were resistant to irradiation.

#### CASE REPORT

A thirty-year old white male was admitted to the hospital on January 9, 1948, complaining of gnawing and mid-epigastric pains of three months' duration. There were associated nausea and anorexia and a 13 pound weight loss had occurred.

Physical examination revealed a tender, movable mass in the epigastrium. The complete blood count including differential was normal. Urinalysis and gastric analysis were also normal. Roentgenograms revealed a large ulcer along the lesser curvature of the stomach. (Fig. 1.) Gastroscopy confirmed this finding.

A firm, irregular mass measuring 8 by 3 cm. in size and 4 cm. in thickness with a large central crater occupying the upper two-thirds of the lesser curvature of stomach was found at operation. (Fig. 2.) The lesion had penetrated the stomach wall to invade the left lobe of the liver. An almost total gastrectomy and partial resection of the left lobe of the liver was accomplished. All of the regional and palpable nodes were removed.

The microscopic sections (Figs. 3 and 4) revealed sheets and strands of oval and spherical neoplastic cells, larger than mature lymphocytes, containing large oval or indented nuclei which were hyperchromatic and displayed many mitoses. The lymph nodes revealed the same changes.

Three weeks following surgery he developed a nodule in the lateral aspect of the wound which on biopsy studies was positive for malignant lymphoma. Additional studies revealed no other areas of extension. The patient was given irradiation therapy to the upper abdomen and both inguinal regions. There was no improvement. He continued a rapidly progressive downhill course with complaints of headaches and nausea; jaundice also developed. Blood counts and smears remained normal but the patient expired on May 21, 1948.

The autopsy revealed neoplastic cells, even more anaplastic than those found in the surgical specimen, which had involved the following

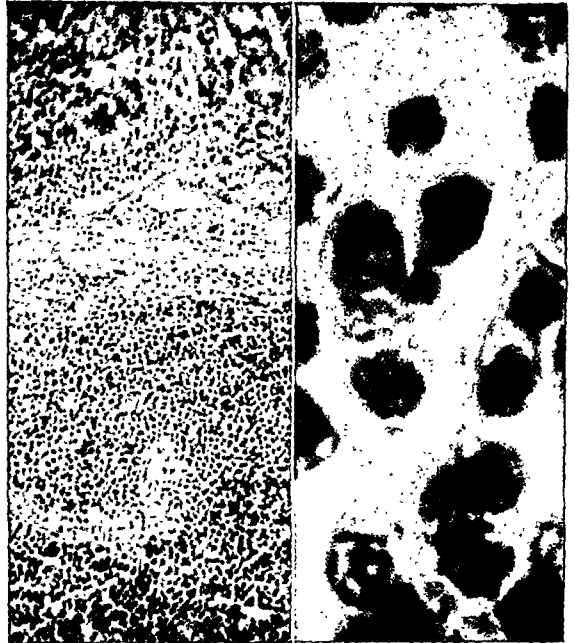


FIG. 3

FIG. 4

FIG. 3. Submucosa, stomach wall, showing diffuse infiltration by neoplastic cells, hematoxylin and eosin stain. 100 X.

FIG. 4. Submucosa, stomach wall, hematoxylin and eosin stain, higher magnification of Figure 3 which shows the neoplastic cells to be of the lymphoblastic type. 1000 X.

organs: spleen, liver, gallbladder, pancreas, stomach, small and large bowel, thyroid, adrenals, kidneys, bone marrow and peribronchial, mediastinal, retroperitoneal, mesenteric and inguinal lymph nodes.

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H. J. MOERSCH reports twenty-two cases of esophageal varices with bleeding in which patients were treated by injection of a sclerosing solution into the varices via the esophagoscope. About one-half of the patients had recurrent bleeding, probably because varices were also present in the cardiac end of the stomach. The sclerosing solution apparently has no effect on these latter varices. Diagnosis can often be made by x-rays; in doubtful cases the esophageal varices can be seen through the esophagoscope. When varices are also present in the cardiac end of the stomach, the author believes this injection treatment should not be used but rather that portal caval anastomosis be done or even a resection of the lower esophagus and cardiac end of the stomach. Undoubtedly, in properly selected cases this injection of a sclerosing solution may have temporarily beneficial results. However, it does not remove the primary cause of the trouble, hence, portal caval anastomosis, when it can be done safely (in expert hands), is the treatment of choice. In my opinion, therefore, the injection method must be considered as palliative treatment only. However, it may well be worth while if it tides the patient over for the next few years because by that time the technic of radical therapy (or portal caval anastomosis) will become well standardized and by that time the patient can be submitted to this operation with a greater prospect of final cure and with a lower operative mortality than at present. (*Richard A. Leonardo, M.D.*)



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# Case Reports

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## ENTEROGENOUS CYST OF THE DUODENUM\*

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**D**UPLICATIONS of the small intestine, likewise referred to as enterogenous cysts, are extremely rare. Over half the cases occur in the small bowel and of this group half are in the ileum. Ladd has reported four cases of the ileum and one each of the stomach, duodenum and jejunum. Most of these cysts occur on the mesenteric border of the bowel. This case, however, was situated on the anti-mesenteric side.

As to the mode of origin of these cysts, no single theory can satisfactorily explain all the cases observed. In brief, the suggested mode of origin is: (1) They result from aberrations in the development of a Meckel's diverticulum. (2) The second mode of origin that has been stressed by Ladd and Gross is that these cysts have their origin in diverticula at various intestinal levels. (3) Failure of complete vacuolization of the solid intestinal lumen in fetal life in which a chain of vacuoles may coalesce but not unite with the main lumen, thus producing two separate lumina.

The symptoms are usually those of intestinal obstruction, either partial or complete, and may occur in either very early infancy or in adult life depending upon the size and location of the tumor mass. The treatment is surgical and one of the following procedures is recommended: (1) resection; (2) enucleation; (3) marsupialization; (4) as recently suggested by Gross, anastomosis to the intestinal tract.

### CASE REPORT

This female (M.K.) was born on November 29, 1941, and from the first day of life vomited

almost all of her feedings. Five days after birth a rounded cystic tumor mass about 3 cm. in diameter was palpated in the right upper abdomen in the location where one would ordinarily expect a mass suggestive of hypertrophic pyloric stenosis. Gastrointestinal series as indicated in Figure 1 showed a rounded shadow anterior and lateral to the first portion of the duodenum, with compression of the underlying intestine causing a partial obstruction. This child was treated for several days for possible pyloric stenosis but lost weight rapidly; therefore, on the fourteenth day of life exploratory laparotomy was performed. A large cystic mass was found anterior and lateral to the first portion of the duodenum, intimately attached to the bowel with a common muscularis and what proved to be a separate mucosa. The cyst was opened and a considerable amount of clear mucus was aspirated. There was no communication with the underlying duodenum. Because of the extremely poor condition of the child a marsupialization procedure was carried out in which the cyst wall was anchored to the anterior abdominal wall and then carefully packed with gauze. The child made an uneventful recovery but mucus drainage from the cyst continued until the present report.

At this writing the external opening is very small and the cyst requires daily aspiration which usually produces about 10 to 20 cc. of clear mucus. The child is now six years of age and is a healthy, robust little girl. On October 7, 1946, at the age of five years, she was admitted to the hospital with acute upper intestinal obstruction as indicated in Figure 2. A laparotomy was performed and several coils of jejunum were freed. Following this procedure an uneventful recovery was made. Figures 3 and 4 were made by the injection of lipiodol into the cyst cavity. It is clear that this cyst is located anterior and lateral to the first portion of the

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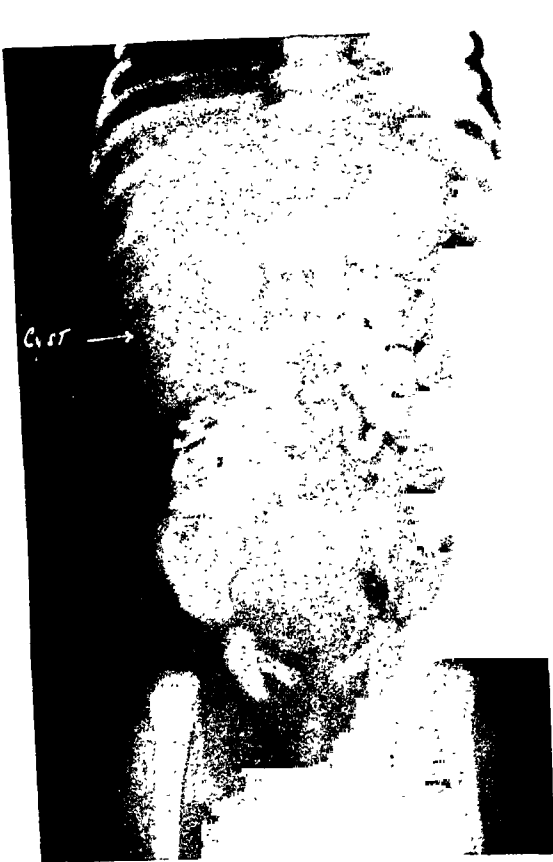


FIG. 1



FIG. 2

FIG. 1. Barium in the stomach and small intestine shows filling defect and partial obstruction in the first portion of the duodenum.

FIG. 2. Acute dilatation of stomach and loops of small intestine present at second admission at the age of five. The point of obstruction is in the region of the enterogenous cyst.

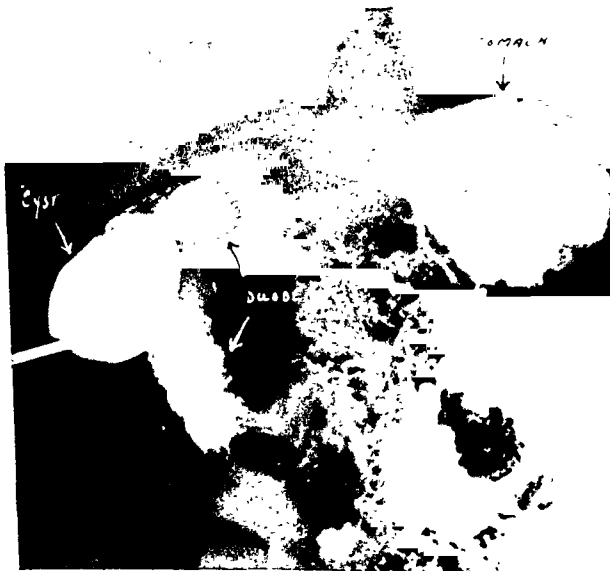


FIG. 3



FIG. 4

FIG. 3. Barium in the stomach and duodenum and lipiodol in the cyst cavity. This indicates that the position of the cyst is in the antimesenteric border and is located between the first and second portions of the duodenum.

FIG. 4. Lateral view with lipiodol outlining the cyst cavity and showing the cyst in an anterior position with air in the underlying duodenum.

duodenum and that it does not obstruct the underlying bowel. At some future date an attempt will be made to establish a common channel between the cyst and the duodenum as suggested by Gross.

#### COMMENT

This lesion is rarely diagnosed preoperatively because it is seldom considered in the differential diagnosis of vomiting in the newborn. Such congenital abnormalities as omental, pancreatic and dermoid cysts, and hypertrophic pyloric stenosis are usually the most common lesions diagnosed.

The treatment of these lesions is surgical and the method employed depends upon the individual case. The factors of age, condition of the patient and location of the lesion determine the type of operation to be performed. We believe that conservative treatment, either by marsupialization of the cyst or its anastomosis to the gastrointestinal tract is indicated in the newborn and the very young whose chance of survival from more radical surgery is questionable. The common dangers from resection

and extirpation has been fully discussed by other authors.

#### SUMMARY

1. We have presented a case of enterogenous cyst of the duodenum, the fifteenth case so reported. We believe that this is the youngest case which has survived any operative procedure for enterogenous cyst of the duodenum.
2. The diagnosis and treatment have been discussed.
3. Marsupialization is the treatment of choice in the newborn and very young.

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# FAT EMBOLISM FOLLOWING ABDOMINAL SURGERY\*

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THE subject of fat embolism in its relation to severe trauma and fractures is fairly well covered in the literature but its occurrence following abdominal surgery, which is relatively atraumatic, has been overlooked or misdiagnosed. That fat embolism occurs following operative incisions and surgical dissection on obese persons has been mentioned by Ferguson<sup>1</sup> and Bissel.<sup>2</sup> In my brief experience fat embolism following abdominal surgery has been encountered twice. The second is a rather rare case in that the patient apparently suffered a similar disturbance following abdominal surgery six years previously.

## CASE REPORTS

A woman, Mrs. A. C., aged thirty-one, weighing 174 pounds, was admitted to the hospital on April 15, 1946, with complaints of pain in left lower quadrant and dysmenorrhea. The onset of the present illness occurred approximately three months following a pelvic laparotomy six years previously. She complained of considerable pain just before and with her period and also of constant left lower quadrant pain and fullness.

In 1936 she underwent an appendectomy and made an uneventful convalescence. In 1940 she had a right salpingectomy and a partial right and left oophorectomy under ether anesthesia; the postoperative course was stormy. Six hours postoperatively her temperature rose to 107°F. and remained between 105° and 107°F. for approximately eighteen hours and subsided by lysis. Simultaneously with the temperature rise the pulse rose to 180. The patient was dyspneic with a slight cough; the blood pressure was 70/0 for five hours. The patient was quite restless during this time. Examination revealed nothing of significance in either the chest or abdomen. A chest x-ray was taken at that time and was reported as negative. After

approximately seventy-two hours in a critical condition the patient made a complete recovery. No urine examination for fat was carried out at that time.

Physical examination at the present admission was essentially negative except for a large, pendulous abdomen measuring 40 inches in circumference and, on pelvic examination, a cystic mass the size of a grapefruit in the left adnexal region. Laboratory findings were essentially normal and a preoperative diagnosis of left ovarian cyst was made. On April 16, 1946, she was operated upon under ether anesthesia. Through a left lower abdominal transverse incision, lysis of adhesions, removal of a left intraligamentary ovarian cyst, partial salpingectomy and removal of several areas of endometriosis were carried out with only moderate difficulty. Fifteen hours postoperatively the patient became restless, the blood pressure dropped slightly and the pulse rose to 120. Examination at this time was negative. On the twenty-fourth postoperative hour the temperature rose suddenly to 105°F., and the pulse became weak with an approximate rate of 150. The blood pressure dropped to 90/60 from a previous 120/80. The patient was quite restless with moderate dyspnea, a slight cough and considerable cyanosis. Examination of the abdomen and chest at this time was essentially negative. The patient did not appear as sick as her pulse and temperature indicated. An x-ray of her chest was essentially negative. Examination of the urine carried out at this time showed it to be loaded with fat droplets. Fat continued to be present in the urine for the next twenty-four hours and suddenly ceased. For forty-eight hours the patient's pulse was quite weak and rapid; she was very irritable and from time to time facial twitchings were noticed. A faint, blotchy petechial rash appeared on the arms and shoulders around the thirty-sixth hour and gradually faded, disappearing on the fourth day. Heart tones were weak and rapid but there were no audible murmurs. The chest

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remained clear throughout. The temperature varied between 103° and 105°F. for approximately twenty-four hours and then fell by lysis to normal eighty-four hours postoperatively. The course thereafter was entirely uneventful; the wound healed per primam and no complications or sequelae were observed. The patient was discharged on the eleventh postoperative day. Therapy consisted of cedilanid intravenously and digalin intramuscularly, oxygen tent, salicylates, sponges, and penicillin. One-sixth molar sodium lactate solution and 10 per cent glucose in water were administered intravenously. Urinary output was maintained around 1,000 cc. for each twenty-four hours.

A white woman, Mrs. E. S., age sixty-seven, was admitted to the hospital on April 2, 1949, with typical gallbladder complaints and a history of two short episodes of jaundice in the past year and previous coronary disease. Physical examination revealed the patient to be obese, weighing 167 pounds, height 4 feet 11 inches, with moderate right upper quadrant tenderness and blood pressure 140/100; the systolic murmur was heard at the apex of the heart.

Laboratory examination, including liver function tests, were within normal limits. Chest x-ray showed moderate aortic dilatation. An electrocardiograph showed a left bundle branch block and other findings indicative of an old coronary occlusion.

In spite of the patient's poor condition, operation was decided upon because of the severity of her symptoms. On April 7, 1949, under spinal anesthesia a cholecystectomy, choledochostomy, exploration of the common duct with removal of three stones and T-tube drainage were carried out. The pathologic report on the gallbladder revealed chronic cholecystitis with multiple lithiasis.

The postoperative course during the first twenty-four hours was uneventful; pulse rate 100. Thirty-six hours postoperatively, her pulse suddenly became rapid to 140; the patient was very restless, mildly dyspneic and upon examination of the chest, numerous rales were heard in both bases. Her blood pressure was 106/70; a chest x-ray was negative.

Diagnosis: Early left heart failure.

The patient was placed in an oxygen tent and rapidly digitalized with cedilanid. In spite of digitization, fluids, penicillin, et cetera, the patient's course was downward; her pulse

remained slow temporarily then increased again. Hyperthermia began thirty-six hours postoperatively and spiked to 104.2°F., followed by a second spike to 106.8°F. The restlessness and irritability increased and death occurred eighty-four hours postoperatively. Urinalysis revealed a urine loaded with fat. Autopsy revealed acute left heart failure resulting from fat emboli (multiple). A satisfactorily healing operative site and wound were found.

#### COMMENTS

The reasons why fat embolism following abdominal surgery is often overlooked or misdiagnosed are: clinically, it is difficult to substantiate conclusively; it is rarely considered as a possible complication even in traumatic surgery.

Knowledge of the etiology, pathology and methods of diagnosis of fat embolism should prove an aid in correct diagnosis and should put the surgeon on the alert for fat emboli following abdominal surgery.

Fat embolism as defined by Vance<sup>5</sup> is "the introduction of liquified fat into the circulation and its transportation by the blood stream to occlude the fine blood vessels in various parts of the body." The condition may be classified into three groups: (1) subclinical in which the amount of fat in the blood is so small that clinical symptoms are absent; (2) clinically manifest non-fatal cases in which there are definite cerebral or pulmonary manifestations, or both, as well as symptomatic and (3) severe or fatal types in which such a large amount of fat is present or the patient's condition is such that death ensues due to circulating fat.

Much experimental work has been done on the causation of fat embolism by Scuderi,<sup>4</sup> Vance,<sup>6</sup> Scriba<sup>7</sup> and others. No definite conclusions have been reached but a statement of a few observations in connection with fat embolism may serve to clarify the etiology and pathogenesis. The fat which causes embolism is not the same as that which is normally emulsified and carried in the blood stream.<sup>3</sup> At body temperature oleic acid, one of the three acids produced by a breakdown of fat, is a fluid

and, therefore, more readily taken up by the blood than the other two acids, palmitic and stearic, which are semi-fluids. The mechanical factor of blocking in small vessels occurs mostly in the lungs; apparently the change of some of the emboli from fat droplets to their constituent acids occurs there with distribution of oleic acid into the general circulation.<sup>5</sup> It is believed by some that the real damage of fat embolism is produced by the breakdown of the fat to its acids and the free circulation of oleic acid which has definitely been proven toxic to the myocardium and an irritant to the brain.

Experimentation by Lehman and Moore<sup>8</sup> would seem to indicate that fat in amounts of from 100 to 120 cc. was necessary for a lethal outcome. This work was done on dogs using injections of cottonseed oil. From such experiments it might be inferred that something besides fat droplets is necessary to produce a lethal result in the human since it has been definitely shown that the femur in man contains only approximately 65 cc. of liquid fat. However, many proven cases of fatal fat embolism have occurred from trauma in this region.

The role of alcohol and ether in the production of fat emboli by aiding in the liquification of fat is still undetermined. Cubbins<sup>9</sup> believes that fat embolism is more common in injured persons after an alcoholic debauch. Neither alcohol nor ether is of any value in the treatment of this condition according to all authorities on the subject.

In the production of fat embolism several factors must be presents imultaneously: first, liquefied fat; second, an open vein with enough negative pressure to draw in this liquified fat. These circumstances are most commonly encountered in orthopedic, traumatic and fracture work but also may be encountered in lower abdominal surgery, specifically when large varicosities are present in the broad ligaments or in the deep sacral dissection of an abdomino-perineal resection of the rectum. In the latter oper-

ation there may be large amounts of liquified fat and often large sacral veins are opened which may only slowly retract into their foramina. Probably a number of sub-clinical and non-lethal clinical cases occur following this type of surgery and very often go unrecognized. In this connection one must bear in mind the possibility that lymphatic absorption may be another route of entrance for fat particles into the blood stream. This idea has been suggested and has some evidence in its support.<sup>10</sup>

The pathogenesis is briefly that fat droplets which are picked up in the venous or lymphatic circulation are returned to the lungs and from there distributed over the entire systemic circulation. The three most commonly involved sites other than the lung are the heart, brain and kidney.

On section of an involved lung fat may be seen in the arterioles and capillaries. It appears as globular masses obstructing the vessel lumen. The damage is entirely mechanical and the degree of pulmonic embarrassment is proportional to the amount of lung involved. Two different methods of transfer of the fat or its constituent acids into the general circulation have been advanced. First, in as high as 33 per cent of all necropsies a small slit may be found in the region of the foramen ovale; and while under normal conditions no blood ever passes through this slit, certain investigators<sup>11-13</sup> have expressed belief that due to a rise in pulmonary pressure fat may be forced through this slit in the intra-auricular wall. Second, the most important transfer probably occurs between the pulmonary capillaries and the pulmonary veins.<sup>6</sup>

In the heart coronary blockage may occur but is not common. However, circulatory failure is quite marked in most cases even without evidence of coronary blockage and, therefore, several investigators have suggested toxic myocarditis from oleic acid as the cause of heart failure. Massive pulmonary involvement will, of course, cause the right heart to fail. Simonds<sup>14</sup> associated fat embolism with

peptone shock but his work was not conclusive.

Since the brain contains many small vessels, many plugs would be expected when the brain is the site involved. However, such is not the case. The gray matter is first invaded by the emboli and the resultant pathologic lesions consist of congestion and a few petechiae. These petechial hemorrhages are believed to be evidence of minute infarction. Because of a disproportion between symptoms and lesions, the toxic effect possibly from circulating acid again is to be considered. Fat emboli can be demonstrated in the vessels of the brain on cut section. In support of the toxic effect Buerger<sup>15</sup> states that lesions of the gray matter can be demonstrated only in those brains already damaged by disease processes.

Scriba<sup>6</sup> called attention to fat droplets in the urine in cases of fat embolism but not one of the many theories proposed as to how the fat is excreted by the kidney has ever been proven. However, excretion of fat in the urine is a most important way of getting rid of intravascular fat. This is a known fact and, therefore, is a positive diagnostic sign of fat embolism.

The onset of symptoms associated with fat embolism usually occurs from six to forty-eight hours postoperatively but may be delayed as long as seventy-two hours. It is preceded by moderate cyanosis and dyspnea followed shortly by a rising temperature which may go as high as 107°F.; simultaneously the pulse becomes weak and rapid and the blood pressure may drop to alarming levels. Several hours after the onset restlessness, irritability, twitching, delirium and coma may appear. The degree of cyanosis and dyspnea is dependent upon the amount of pulmonary impairment. The average temperature peak varies between 103° and 105°F. and in non-fatal cases usually begins to drop by lysis within thirty-six hours. In terminal cases the temperature often rises a second time to a much higher peak than the first. A petechial rash is often seen especially on

the extremities, back and shoulders and is further evidence of an embolic process.

The diagnosis of fat embolism can definitely be made only by the finding of fat in the urine. Scuderi<sup>3</sup> has described a typical x-ray of the chest in these cases but it is generally believed that there are no typical diagnostic findings on x-ray.

In the differential diagnosis one must consider mainly massive atelectasis and cerebral vascular accidents. If these can be ruled out, fat embolism may be strongly suspected. Fulminating peritonitis usually does not give such severe reactions within the first forty-eight hours and can definitely be ruled out on abdominal examination.

As has been pointed out many times by the writers on traumatic fat embolism, careful collection of the urine is necessary in making the diagnosis. It has been shown experimentally that these fat droplets float on the surface of the urine and, therefore, are not excreted from the bladder unless the last few cubic centimeters are expressed. Failure to observe this precaution probably accounts for failure to diagnose this condition more frequently. Blood fat levels and dark field examinations for fat droplets are of no real value in making the diagnosis.

The prognosis is always guarded. If the patient survives the initial onslaught of emboli, he still has to contend with the sequelae and a patient who is progressing fairly well may suddenly die from myocardial failure. Most cases, if they are of lethal variety, will end fatally within ninety-six hours after onset. Just what percentage of patients recover is difficult to say because this diagnosis is made only in the most serious cases, the others being overlooked or misdiagnosed. If recovery takes place, it is complete with no residual effects.

The treatment of this condition, as in any in which no specific measures are available, is directed at supportive measures only. Such things as solvents, saponifiers and enzymes are all too toxic for use on man and are of questionable theoretic

value. Since fat is removed from the circulation in four ways, namely, excretion by the kidney, disposal by the liver, phagocytic action of the reticulo-endothelial system in general and action of blood and tissue lipase, therapy as based on this knowledge is concerned with increase of the urinary output by the use of intravenous sodium lactate solutions plus the supplying of free water to the kidney in the form of 10 per cent glucose, thus maintaining a large urinary output to rid the blood stream of fat.

Digitalization is indicated to support an injured myocardium and oxygen aids in overcoming the debt resulting from pulmonary embarrassment. Penicillin is used to prevent secondary invasion of the lung by common bacteria.

Methods directed at lowering the body temperature are usually of little avail since the disturbance is central in origin. However, the use of salicylates, sponges, etc., may be of some value. The cooling effect of an oxygen tent is very desirable. Stimulants in the form of caffeine, coramine and neosynephrine have value but must be used with considerable caution.

#### SUMMARY

It is shown that in abdominal surgery, which is relatively atraumatic, fat embolism is a possible complication. Two interesting and unusual cases illustrating this fact are presented. The reasons why fat embolism following abdominal surgery is overlooked or misdiagnosed are set forth.

The etiology and pathology of fat embolism are discussed along with the methods of diagnosis, treatment and prognosis. If these things are kept in mind and careful urine examinations for fat made in any suspected case, the diagnosis will be made much oftener.

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# TENSION GANGRENE OF THE CECUM DUE TO CANCER OF THE SIGMOID

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WHEN strangulation obstruction of the large bowel is excluded, the chief factor affecting the viability of the intestinal wall in the majority of obstructions is increased intraluminal pressure from colonic distention. The resulting pathologic condition is gangrene. Thereupon perforation may occur anywhere along the colon at varying distances proximal to the obstructing lesion.

Such an obstruction of the colon differs from a similar obstruction of the small intestines because the ileocecal valve may prevent regurgitation of the contents of the large intestines into the ileum.<sup>1</sup> This condition predicates the presence of intraluminal content plus the pouring of ileal content into the colon with no avenue for escape (closed loop obstruction).<sup>2</sup> (Fig. 1.) The effect of the ileocecal sphincter in the presence of obstruction has been demonstrated experimentally.<sup>3</sup> The importance of the ileocecal valve and sphincter in causing "diastasis" perforation was first stressed in 1880.<sup>4</sup> It was reiterated in 1902.<sup>5</sup> It is noted that in the past two decades surgeons have again become interested in the presence and importance of gangrene proximal to carcinoma of the colon. At operation damage to the large bowel proximal to the lesion must be determined. It was noted in 1934 by Wangenstein and his associates that the vast majority of perforations of the colon were in the cecum regardless of the site of obstruction. Black and Evert<sup>6</sup> observed three perforations situated at or very near the obstructing lesion. The perforations were within 3 cm. of the lesion. The lesions were adenocarcinomas located within a distance of 11 to 22 cm. above the anus. The same authors also present an additional twenty-nine cases that were

selected from among forty-eight cases originally reported.<sup>7</sup> Although the cecum was again the most frequent site, other parts of the intestines occasionally perforated (Table 1.)

TABLE I  
SITES OF MALIGNANT PERFORATION OF THE COLON IN TWENTY-NINE CASES

Site of Perforation	Site of Obstructing Lesion			
	Rectum	Sigmoid	Splenic Flexure	Transverse Colon
Sigmoid.....	3	1		
Descending colon...	..	1		
Splenic flexure.....	2			
Transverse colon...	2	4	2	
Ascending colon....	..	1		
Cecum.....	1	4	6	2

The findings of a number of authors support the opinion that the stress which is borne by the dilated gut is in direct proportion to the intestinal diameter. Wangenstein figured the tension (T) on every cm. of surface of the segment as equal to the diameter (D) in cm. multiplied by pi times the enteric pressure (P) in cm. of water. Applying an intra-enteric pressure of 24 cm. of water, which is within the limits of pressures measured in similar cases, Wangenstein arrived at a stress factor or tension of 735 cm. in the cecum and 340 cm. in the descending colon. Therefore, he concludes that the frequency with which perforation of the cecum is observed in obstruction of the pelvic colon is apparent and is due to the difference of stress or tension exerted on the walls in segments of varying diameters.

As tension increases the colon is stretched to its limits and the blood vessels of the

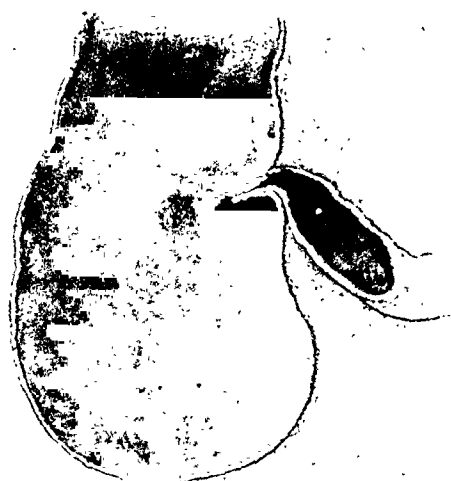


FIG. 1. Shows ileocecal valve sealing off the colon. (From Owen H. Wangensteen's "Intestinal Obstructions." Springfield, Ill., Charles C. Thomas.)

distended loop become lengthened and narrowed.<sup>8</sup> With every unit of increase in diameter, a threefold increase in circumference of the colon occurs. Thus the blood vessels are subjected to a process of elongation in a 3 to 1 ratio with the changes in intestinal diameter.<sup>9</sup>

It is evident that the return of venous blood will diminish in the presence of narrowing and elongation of the blood vessels. In experiments on six dogs Gatch and his associates<sup>10</sup> observed an average return flow of 3 cc. of blood per minute in the mesenteric vein of an isolated intestinal loop when 200 mm. Hg of intraluminal resistance were offered. The return flow without any resistance was six times as much, namely, 18 cc. As the applied pressure of 200 mm. mercury is in considerable excess of the blood pressure of dogs, (1 mm. Hg being equivalent to 1.3 cm. of water) these authors thus proved that the mesenteric circulation is retarded but not entirely arrested by increased intra-enteric pressure.

Whereas a moderate or physiologic degree of intraluminal pressure is considered a most effective stimulus for gastrointestinal motility,<sup>11</sup> excessive intraluminal pressures are responsible for interference with the blood supply of the distended region

and simultaneously lead to a general inhibition of the intestinal motility.<sup>12</sup>

As previously stated the symptoms of large and small bowel obstructions can be differentiated frequently on the basis of the behavior of the ileocecal valve and sphincter. It is the "check valve" nature of the ileocecal juncture which changes the obstructive colon into a "closed loop." The contents of the small intestines freely enter the colon, but regurgitation from the colon into the small intestines does not occur frequently.

At this state our chief interest is the viability of the bowel wall. In man high intra-enteric pressures which endanger the circulation of the bowel accompany acute clinical cases of obstruction of the colon. The large bowel can be greatly dilated without interference to its circulation,<sup>13</sup> but it will suffer, become necrotic and rupture when the pressure within it approaches the diastolic blood pressure.<sup>14</sup> Damage to the large bowel wall is often observed at operation.

The following is a synopsis of the local effects of sustained increased pressure in the presence of "closed loop" obstruction of the colon compiled from the various reports of authors:

- |   |  |
|---|--|
| 1. Increase in intraluminal contents of gas and fluid | A: Increase in intraluminal pressure   |
| 2. Increased motor activity of the bowel              |  |
| 3. Distention and intestinal stasis                   |  |
| 4. Thinning of the intestinal wall                    |  |
| 1. Decreased absorption from the intestinal lumen     | B: Histologic evidence of local injury to the intestinal wall with increased permeability leads to tension gangrene and its sequela of perforation and peritonitis |
| 2. Venous stasis in the bowel wall                    |  |
| 3. Anoxemia   |  |
| 4. Impaired viability                                 |  |

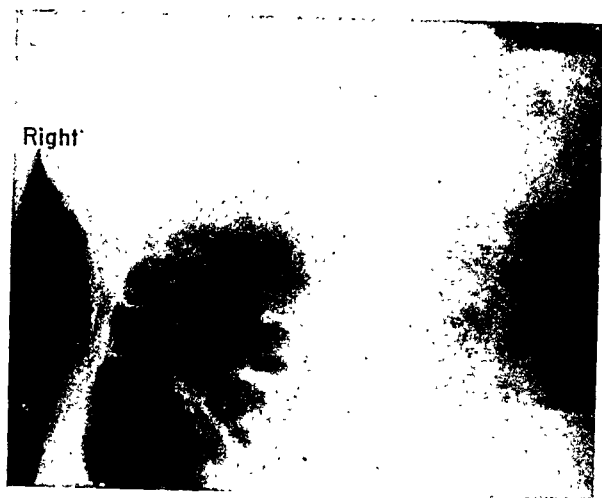


FIG. 2



FIG. 3

FIG. 2. Flat plate of abdomen showing marked distention of the right colon with fluid levels in the left colon.

FIG. 3. Barium enema study accomplished with the injection of barium through the rectum and colostomy opening, oblique view; report filling defect in the mid-sigmoid area with marked dilatation of the rectum and the lower sigmoid.

The left half of the colon is eight times as often the site of a lesion as is the right half.<sup>15</sup> In several reported series of both acute and chronic obstruction the incidence of obstruction varies from  $33\frac{1}{3}$  to 39 per cent in cases of carcinoma of the colon.<sup>16,17</sup>

Of 2,730 patients with operable malignant lesions of the colon, 5.5 per cent had acute obstruction.<sup>18</sup> A much higher percentage (35.6 per cent) of acute obstruction in cases of carcinoma of the colon is reported by Burgess.<sup>19</sup>

The diagnosis of acute obstruction of the large bowel is made in the presence of the following: (1) Distention is usually present. (2) Vomiting is not frequent because the colon is sealed off by the ileocecal valve and thus is not decompressed by regurgitation into the small intestines; therefore, the stomach will often be found empty upon tubal drainage. (3) Abdominal palpation or rectal examination may reveal a palpable tumor mass. (4) When tenderness is present, it is usually found over the cecum. It is a warning that viability of the gut is threatened. (5) Pain occurs more frequently in the overstretched area than at the site of the obstruction. (6) Peristalsis may be visible or palpable; as the intraluminal pressure increases, peristalsis may become entirely inhibited. (7) In x-ray the

barium enema may be of great help in searching for the site of the obstruction. However, instances are known in which in the presence of great distention the barium failed to reveal the lesion because it by-passed the stenosis. In acute obstruction the presence of fluid levels is pathognomonic.

#### CASE REPORT

H. F., a white female aged fifty-two, was admitted to the Norwegian Hospital on June 22, 1944. There had been increasing constipation and belching for the previous two years. During the four days prior to admission the patient had suffered from diffuse abdominal pain and inability to move her bowels. A citrate purge had had no results. Physical examination showed the abdomen to be distended with marked tenderness over both lower abdominal quadrants. Borborygmi were heard throughout the abdomen. Vomiting was absent. The temperature varied between 100 to 101°F., the pulse rate between 90 to 100 and the respirations were 24. The blood pressure was 138/78. The urine showed 3 to 4 plus acetone. The red blood count was 4,300,000 83 per cent polymorphonuclears and 17 per cent lymphocytes. X-ray studies were made and revealed marked distention of the right colon with fluid levels in the left colon. (Fig. 2.)

Surgical intervention was finally permitted on June 25, 1944. The cecum was found to be



FIG. 4

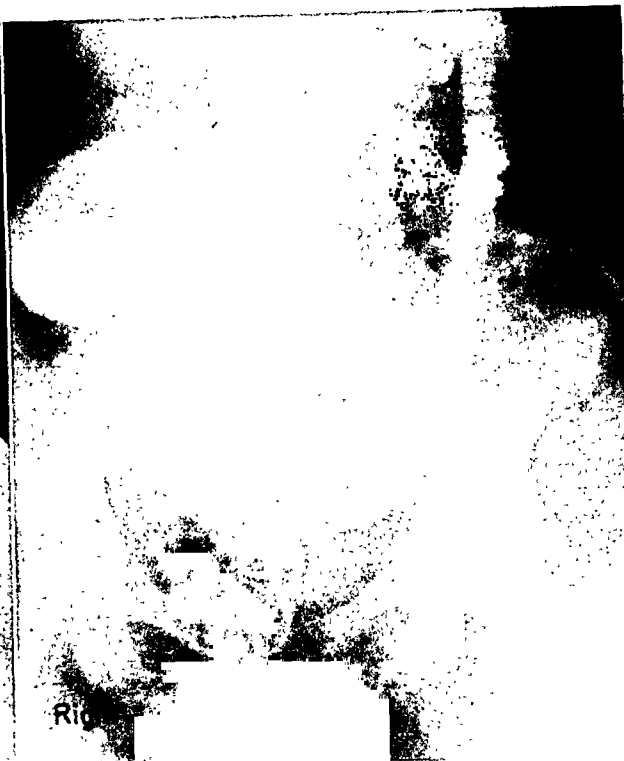


FIG. 5

FIG. 4. Barium enema after resection of the sigmoid with filling accomplished only through the rectum showing a dilated rectum and sigmoid and continuous barium stream to the right colon.

FIG. 5. Barium enema study prior to closure of fistula showing functioning large bowel without obstruction along its course.



FIG. 6. Barium enema study after closure of fistula showing functioning large bowel by passage of barium into small bowel.

greatly dilated, its wall was permeable, black and friable. The lumen was filled with sludge. The large bowel was dilated throughout and in the sigmoid a napkin ring lesion was noted. The liver was not palpated. Thereupon, 6 inches of the ileum, cecum and ascending colon were removed. The colon and ileum were exteriorized, 4 Gm. of sulfanilamide were dusted into the peritoneal cavity and the wound was closed in layers. The patient's postoperative course was satisfactory and she was discharged as improved on July 24, 1944.

Upon readmission to the hospital on October 25, 1944, her general condition was good and the state of the apertures of the colostomy and ileostomy was excellent. Barium study revealed a filling defect in the mid-sigmoid area with marked dilatation of the lower sigmoid and rectum. (Fig. 3.)

On October 30, 1944, resection of the sigmoid with an end-to-end anastomosis was performed. Palpation of the liver was waived due to adhesions. The pathologic findings were a napkin ring lesion of the sigmoid which microscopically showed itself as an adenocarcinoma, grade II. A subsequent barium

enema on November 8, 1944, showed a dilated rectum and sigmoid with a continuous barium stream to the right colon. (Fig. 4.) After a Stetson clamp had been applied to the spur of the ileocolostomy on November 27, 1944, the spur was found to be essentially destroyed eight days later. The patient was discharged on December 20, 1944, having satisfactory bowel movements although a small amount of feces was noted to escape through a fistulous opening at the site of the former ileocolostomy. This fistula was closed on June 11, 1945. A barium enema study just prior to the closure showed a functioning large bowel without any obstruction along the rectum, sigmoid, descending or transverse colon. (Fig. 5.) On June 21, 1945, the patient was discharged as recovered, having satisfactory bowel movements. The abdominal wound had healed well. An interval barium enema study was done on June 18, 1946, and showed a functioning large bowel with passage of the barium into the small bowel. (Fig. 6.)

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# CYST OF THE PERICARDIUM\*

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ADVANCES in thoracic surgery have been such that thoracotomy for unexplained lesions parallels that of celiotomy for similar lesions of the abdomen. Circumscribed or "coin" lesions can often be diagnosed only in this manner even in face of bronchoscopy, tomography and diagnostic pneumothorax and pneumoperitoneum. During such operations numerous unusual tumors and cysts have been encountered. Sixteen cases of pericardial cysts have been described; they are sufficiently unusual to warrant this additional report.

## CASE REPORT

A. E., a fifty-two year old white woman, was admitted to the Mount Vernon Hospital on August 23, 1948, for the treatment of an intrathoracic tumor discovered on routine x-ray film. The patient was completely asymptomatic. There were no abnormal physical findings. Radiographic examination of the chest (Figs. 1 and 2) reveals a well circumscribed mass in the right cardiophrenic angle. It lies in the middle mediastinum and is sharply demarcated. The right diaphragm moved normally on fluoroscopy. There were no bronchoscopic abnormalities. Aspirated bronchial secretions were negative for tumor cells. The preoperative diagnosis was mediastinal cyst or tumor.

On August 25, 1948, under endotracheal anesthesia, the right pleural space was entered through a submammary incision in the bed of the third intercostal space. The third and fourth costal cartilages were divided. The cystic mass was pedicled on the parietal pericardium at the level of the inferior pulmonary vein just posterior to the phrenic nerve. At the point of pericardial attachment the stalk measured 0.5 cm. The cyst measured 8.5 by 6.5 cm.; the lining was tissue paper thin and contained clear

fluid. The fluid in the cyst could not be expressed into the pericardium through the stalk. The cyst was removed intact between two clamps and the chest wall was closed in layers without drainage. The postoperative course was completely uneventful.

Microscopic examination (Fig. 3) revealed a cyst wall lined by mesothelial cells lying on a stroma of dense connective tissue containing fat, blood vessels and scattered clusters of lymphocytes. The gross and microscopic findings were characteristic of a pericardial-celomic cyst.

## COMMENT

Dufour and Mourrut<sup>4</sup> in 1929 reported the first case as an incidental finding at autopsy. In 1934 Pickhardt<sup>8</sup> described a pleural-diaphragmatic cyst which he visualized preoperatively by means of diagnostic pneumothorax and thoracoscopy. In 1940 Lambert<sup>7</sup> reported two cases and differentiated pericardial cysts from lymphangiomas. The former are unilocular, well circumscribed and easily shelled out, and derive their blood supply from the pericardium, while the latter are multilocular, intimately adherent to surrounding structures and derive their blood supply from several sources. Lambert states that these cysts arise from "the fact that one of the primitive pericardial lacunae fails to merge with the other, persisted, and developed into a cavity, forming a cyst." Churchill,<sup>3</sup> Greenfield<sup>5</sup> and Lamb<sup>6</sup> described similar cysts. Bradford<sup>1</sup> and Blades<sup>2</sup> reported ten cases from the Army thoracic centers. Only seven cases had been reported prior to Bradford's Army report. No cases of infection or malignant change have been recorded.

\* From the Surgical Service of the Mount Vernon Hospital, Mount Vernon, N. Y.

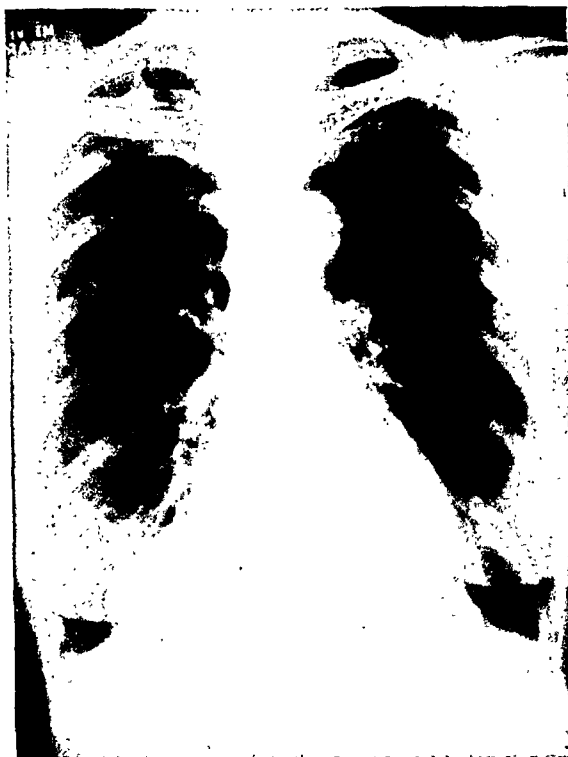


FIG. 1. Anteroposterior roentgenogram showing a smooth, well circumscribed shadow in the right cardiophrenic angle.



FIG. 2. Lateral roentgenogram shows this shadow to be in the middle mediastinum blending with the silhouette.

The reported cases are analyzed as follows:

Sex:	Male.....	9	
	Female.....	6	
	Not stated.....	2	
Side:	Right.....	8	
	Left.....	8	
	Not stated.....	1	
Symptoms:	None.....	10	
	Cough.....	1	
	Dyspnea.....	2	
	Precordial pain.....	3	
Age:	Youngest.....	29	
	Oldest.....	65	
	Average.....		Male..... 36.1 Female.... 48.4

The cyst is of little consequence except in the differential diagnosis of space-occupying lesions of the mediastinum. If the diagnosis can be positively made by thoracoscopy, operation is not indicated. When a more significant lesion can not be ruled out, exploratory thoracotomy is indicated. Excision is usually not difficult and no operative mortality has been reported.

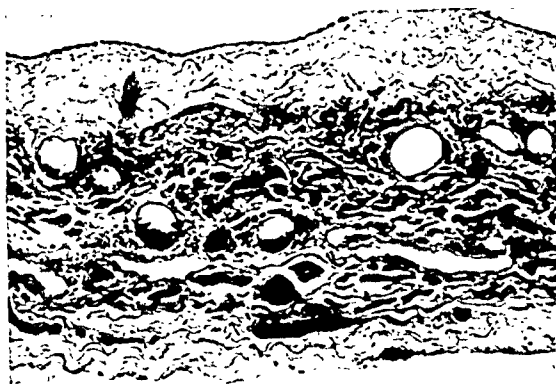


FIG. 3. Microscopic section of the cyst wall demonstrating a smooth endothelial lining on a stroma of connective tissue containing fat, blood vessels and collections of lymphocytes.

#### SUMMARY

1. Pericardial-celomic cyst represents a space-occupying mediastinal mass.
2. It is of importance only in the differential diagnosis.
3. In cases of doubt excisional therapy is indicated.

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IN tetralogy of Fallot there is cyanosis associated with congenital heart disease. Pathologically, there is usually pulmonary stenosis, defect of the interventricular septum, hypertrophy of the right ventricle and dextro-position of the aorta. The cyanosis is principally due to the pulmonary stenosis, however, and is greatest when the stenosis is the most marked. For that reason surgical therapy is directed primarily to overcome the effects of this stenosis. W. J. Potts reports his results in thirty-six children in whom he attempted to overcome this cyanosis by directly anastomosing the aorta to either the left or the right pulmonary artery, depending upon the curve of the arch of the aorta. He uses a special technic of his own and states that thirty of the children were greatly improved; two others were partially improved but still were slightly cyanotic. The operative mortality was about 11 per cent. This is an excellent operation in expert hands. (Richard A. Leonardo, M.D.)



# POST-TYPHOID EMPYEMA OF GALLBLADDER

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**T**YPHOID fever is still very prevalent in China. Its clinical course frequently is severe and its complications are common. Perforation and hemorrhage are the surgical complications seen with greatest frequency. Post-typhoid cholecystitis or acute typhoid bacillus empyema of the gallbladder does not often come to light. Garbat mentioned two patients who, during typhoid convalescence, manifested gallbladder symptoms. The gallbladder was removed and a pure culture of typhoid bacilli was obtained from both.<sup>1</sup> While working in the North-West Branch Army Medical School Hospital, Sian, Shensi, China, I encountered two instances of post-typhoid involvement of the gallbladder.

## CASE REPORTS

**CASE 1.** Mrs. H., aged forty-seven years, was admitted to the hospital as an emergency case on February 4, 1944, with the complaint of sudden acute abdominal pain which started twenty-nine hours previously. The pain was very severe and continuous in character. It originated in the epigastrium and extended downward along the right rectus muscle to a point below the umbilicus. Pain also was felt in both hypochondria but did not radiate to the shoulder. The patient had vomited twice after the onset of the pain. The vomitus was moderate in amount, sour and slightly yellow. There had been no bowel movement since the onset of the illness. There had been some belching of gas and occasional passing of flatus per rectum. There were no chills or fever. Urination was normal; no respiratory symptoms were noticed.

The past history revealed that the patient had suffered from severe typhoid fever five months previously. The disease had lasted for nearly two months and had been complicated by bronchopneumonia, acute myocarditis and pyelitis. Seven days before the present

illness the patient had a severe attack of abdominal pain which had lasted for twenty-four hours. There had been no fever.

Physical examination was essentially negative except for slight tenderness in the epigastric region more so on the right. A dose of morphine ( $\frac{1}{10}$  gr.) was given. Pain persisted the next morning but was less severe. Examination of the abdomen showed continuing tenderness in the right epigastrium and spasm of the right rectus muscle as low as a point midway between the umbilicus and pubes. The white count had increased from 12,000 to 13,400 and the polymorphonuclears from 78 to 84 per cent. The signs were less marked at 5 P.M. but the white count rose to 14,000 and then to 17,000 with 95 and 96 per cent polymorphonuclears, respectively. Fever accompanied with slight chilly sensations was noted at 3 P.M. A perforated, posterior wall, gastric ulcer was suspected but the possibilities of cholecystitis and acute appendicitis also were considered. Exploratory laparotomy was strongly recommended.

Under ether anesthesia a high right rectus incision was made. When the peritoneum was opened, a moderate amount of dark blood gushed out. A huge gallbladder the size of a fetal head and yellowish green in color was revealed. The anterior surface of the liver was ruptured over an area about 2 inches long from which fresh blood was oozing constantly. The abdominal cavity contained about 300 cc. of dark blood. A piece of muscle cut from the abdominal wall was sutured over the wound in the liver. About 50 cc. of light yellow translucent fluid was then aspirated from the gallbladder after which it felt much softer. Palpation failed to reveal stones in the gallbladder or common or cystic ducts. The fluid contents could not be emptied into the duodenum by pressure. The gallbladder was sutured to the anterior abdominal wall as the first step in a two-stage drainage procedure. Smear of the aspirated fluid showed gram negative bacilli. Culture proved them to be *Bacillus typhosus*.

The lower two-thirds of the wound were closed in layers by interrupted sutures.

The first dressing was applied on the third postoperative day. The gallbladder was found so shrunken that it scarcely could be seen through the abdominal wound. Incision and drainage was deferred and the patient's general condition improved steadily. There has been no more abdominal pain since the operation.

It seems obvious that the rupture of the liver was a purely mechanical phenomenon due to the drag of the heavy, over-distended gallbladder. It also seems apparent that the true nature of this condition might have been suspected preoperatively had the significance of the preceding attack of typhoid fever been given more consideration.

CASE II. Mrs. W., aged thirty-six years, was seen because of severe pain in the right upper quadrant of the abdomen. On June 9, 1945, three days before admission, the patient suddenly experienced severe abdominal pain followed by nausea and vomiting. The vomitus first consisted of undigested food and then greenish-yellow, bitter fluid. Fever began on the night of June 10th. The pain first started at the epigastrium below the ensiform process and extended to the right upper quadrant along the costal margin. It was intense in character, continuous and accentuated by motion. Simultaneously the patient also experienced pain of a milder nature in the right lower quadrant. Pressure over the right upper quadrant elicited marked tenderness but pressure over the right lower quadrant did not. The patient was attended by a private practitioner who made a tentative diagnosis of acute appendicitis. She was admitted to the hospital at 9 P.M. on June 12, 1945.

The patient's appetite had been much impaired for several days prior to the present illness. She had taken nothing except a slight amount of water after the onset of the pain. There had been one dark yellowish liquid stool. The symptoms had increased progressively from the onset to the time of admission. There was a past history of typhoid fever in July, 1944. The fever had persisted for twenty-five days and the diagnosis had been established

by the clinical course of the disease plus a positive Widal reaction. The patient apparently had recovered without complication. Several months later two sons and one daughter as well as her husband and another relative suffered attacks of typhoid fever.

On physical examination the patient's temperature was 38.3°C. pulse, 98 and white blood cells 21,800 to 22,100. The patient appeared to be a well nourished, rather obese female who was obviously in marked distress. The abdomen was moderately distended and slight bulging of the right side could be seen. There was marked tenderness and rigidity in the right upper quadrant but no mass could be palpated. The sclerae and skin showed no jaundice. Preoperative impressions were acute cholecystitis or acute appendicitis.

Under ether anesthesia a long rectus incision was made. The gallbladder was found to be tremendously enlarged corresponding to the shape and size of a small kidney basin; it was pinkish green. The liver was not ruptured as in the first case. The gallbladder was aspirated and about 50 cc. of straw-colored, slightly turbid fluid which showed gram-negative bacilli were removed. Cultures grew *Bacillus typhosus*. The contents of the gallbladder could not be emptied into the duodenum by squeezing. No mass could be palpated within or in the neighborhood of the gallbladder which was then anchored to the anterior abdominal wall by six interrupted stitches of silk. The wall of the gallbladder was found to be much thicker than that in Case 1. The appendix although showing no gross pathologic change also was removed.

The first dressing was applied on the third day after operation. The wound was clean and the gallbladder shrunken. Incision and drainage were considered unnecessary. The patient made an uneventful recovery and was discharged on June 20th.

The history of typhoid fever in this patient and the successive cases of typhoid appearing subsequently in other members of the family suggest that the patient was a typhoid carrier. Cecil stated that about 80 per cent of the typhoid carriers are women.<sup>2</sup> Unfortunately, bacteriologic examinations of the stools of my patients were never made. Secondary cholecys-

tectomy was advised in each instance but both patients refused.

apparently caused a tear of the anterior surface of the liver.

#### SUMMARY

Two instances of post-typhoid empyema of the gallbladder are reported. In one case, the weight of the large, heavy gallbladder

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WHENEVER a free skin graft seems indicated, Bors and Comarr prefer the "buried epidermis" graft. A Thiersch graft is taken, usually from the patient's thigh, and is cut up into small pieces or "seeds." These are implanted into the ulcerated area after the latter has been properly cleansed for several days with Dakin's solution or another preparation. Ulcers on the legs, knees or on other parts of the body may be treated similarly. It is true that the cosmetic result may be inferior to that obtainable by plastic flap procedures but the method is very simple and takes one-half to three-fourths of the time. The resultant skin covering is also thinner than after plastic flap procedures. But only 10 per cent as much skin need be used with the "buried epidermis" technic to epithelize the ulcerated area completely, whereas 100 per cent of skin has to be used in plastic graft procedures. The former method, therefore, has its advantages. (*Richard A. Leonardo, M.D.*)

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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-eighth Year of Publication

VOL. LXXVIII

OCTOBER, 1949

NUMBER FOUR

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## Editorial

### MENSTRUATION AND ACUTE APPENDICITIS

THE incidence of acute appendicitis during menstruation as seen in the operating room is quite low. The main factor leading to this low figure is the generally accepted view that pain just before or during menstruation is a normal condition and as such can be disregarded except in rare instances. Curtis<sup>1</sup> states that "definite pelvic pain is experienced by approximately 50% of city-dwelling American women; many are forced to go to bed for a day and a still larger number are considerably incapacitated." While this is a fairly safe line of reasoning as evidenced by the uncommonness of serious complications, acute appendicitis must always be kept in mind in acute abdominal pain. The writer has had two cases of acute suppurative appendicitis during active menstrual flow and one other such case has been seen at the Binghamton City Hospital during the last three years. Incidentally, these were the first personally seen in twenty years of active surgical practice.

An interesting viewpoint on appendicitis and the menstrual cycle is that presented by Hollosi.<sup>2</sup> He believes that as a result of the hormonal interrelationship in the mechanism of the menstrual flow, there is increased vascularity and congestion of

not only the pelvic organs but also the contiguous structures including the appendix. In this process a peri-appendicitis is produced as demonstrated by hyperemia of the serosa, both gross and microscopic. He believes, too, that this predisposes to or rather prepares a fertile field for infection and the acute attack, and also that some cases of dysmenorrhea are coupled with a chronic appendicitis and that in these cases removal of the appendix will cure the dysmenorrhea. Hollosi emphasizes this relationship especially in the pelvic type of appendix. His analysis is based on careful clinical and pathologic study of 163 cases of appendicitis. In all but 15 per cent he believes that the hormonal reactions and menstrual changes played a part in the symptomatology. He stresses the need for care in operating for appendicitis at or about the menstrual period unless signs and symptoms indicate an irreversible condition since as a rule the symptoms are due to peri-appendicitis and operation is not necessary. He mentions the well known fact that any operative procedure carries with it some morbidity and even mortality. While there may be some question as to the acceptability of some of his opinions, the line of surgical treatment advocated is that practiced generally.

The following case reports bear upon this hypothesis:

<sup>1</sup> CURTIS, A. H. *A Textbook of Gynecology*. 5th ed. Philadelphia, 1946. W. B. Saunders Co.

<sup>2</sup> HOLLOSI, K. Appendicitis and menstruation. *Monatschr. f. Geburtsb. u. Gynäk.*, 106: 187, 1937.

An unmarried female, aged twenty-eight, was seen with a history of acute diffuse abdominal pain of twenty-four hours' duration. The pain had become localized in the right lower quadrant for three hours. She was nauseated and vomited the day previous but not on the day of admission. She had a normal bowel movement the previous day but none on the day of admission. She had had no previous similar attacks. A normal menstrual period began three days before (usual length five days) and she was still flowing. The flow was normal in all respects. During the previous three months there had been an increasing amount of dysmenorrhea.

Physical examination was negative except for acute localized rigidity and muscle spasm over the entire lower abdomen especially on the right. There was no tenderness on rectal examination when moving the cervix. Her temperature was  $99\frac{1}{2}^{\circ}\text{F}$ . orally. White blood cells were 14,500 with 90 per cent polymorphonuclears. Urinalysis was normal. A diagnosis of acute appendicitis was made and at operation the appendix was found bound down in the pelvis and completely surrounded by small bowel and cecum. It was gangrenous throughout and showed multiple points of perforation from which pus was oozing. It was removed in a routine manner and the abdomen closed without drainage. Convalescence was uneventful. The microscopic report showed acute suppurative appendicitis and peri-appendicitis with necrosis.

A white, unmarried female, aged forty-one, was admitted with a history of abdominal pain of twenty-four hours' duration beginning one hour after supper. There had been a "grinding" pain continuously since then. The pain had remained in the same area and was not accompanied by nausea or vomiting. Bowel movements were normal and she had no urinary distress, chills or fever. Her temperature was  $100.4^{\circ}\text{F}$ . The patient began menstruating two days previously which was one week early. Her previous period was also one week early

and the one before that had been only eighteen days prior. She usually flowed five days and this present period was no different from any of the other periods and there had been no unusual discharge.

Physical examination was negative except for muscle spasm and rigidity over the lower right quadrant with marked rebound tenderness. The rectal examination showed tenderness on the right. The white blood count was 13,250 with 86 per cent polymorphonuclears. Urinalysis was negative. A diagnosis of acute appendicitis was made. At operation the appendix was found to be lying in the pelvis and adherent to the surrounding bowel. It was acutely inflamed and covered with fibrin. The microscopic diagnosis was acute suppurative appendicitis. Convalescence was uneventful.

A white, married woman, aged twenty-seven, was seen because of pain in the abdomen of twelve hours' duration. She complained of feeling chilly. There were no urinary or bowel disturbances. Her periods had been irregular recently, this period being two weeks overdue. She had been flowing for two days and the flow was more profuse but she was not hemorrhaging. She denied that she was pregnant as this delayed period had happened before. She was nauseated but had not vomited and there was no history of previous pregnancies.

Physical examination showed a well developed and nourished white female who looked ill. The abdomen was flat with muscle spasm throughout the lower abdomen and with marked rebound throughout but more so on the right. There was pain and marked tenderness over the right kidney; none on the left. Vaginal examination was unsatisfactory due to muscle spasm. The patient's temperature was  $101^{\circ}\text{F}$ ; white blood count 14,600 with 88 per cent polymorphonuclears; red blood count 4,000,000 with 64 per cent hemoglobin. A differential diagnosis between appendicitis and pelvic inflammation or ectopic pregnancy could not be made. She was therefore put on penicillin and watched carefully. On the following morning her

temperature was down to normal. She continued to flow moderately. Pelvic examination was essentially the same as on the previous day. Forty-eight hours after admission her temperature rose to 101.6°F. and the blood count which had dropped down the following morning rose to 13,500 with 92 per cent polymorphonuclears. In view of the blood count persistent abdominal pain and rigidity, and the elevation of temperature, exploration was done. An acute suppurative condition of the appendix was found, with the appendix the size of a thumb and covered with fibrin. This extended into the pelvis and was completely walled off by bowel. It was removed in the routine manner and the abdomen closed without drainage. The microscopic report was acute suppurative appendicitis. Convalescence was uneventful except for a wound infection which cleared up quickly on being drained.

The diagnosis in this patient was obscured by the irregular menstrual history and the pain over the kidney. Expectant treatment was instituted because it was feared that the patient might have done something to bring on the flow despite her denials. The use of penicillin caused a temporary recession which led us to believe it was a pelvic inflammation. Surgery was decided upon only when it became evident that the patient was becoming worse.

A careful analysis of these three cases reveals some interesting points which in general seem to substantiate the ideas suggested by Hollosi.<sup>2</sup> The attack in each case was in a pelvic type of appendix. In the first case increasing dysmenorrhea was present. The second and third patients showed irregularity of the menstrual function although the flow was normal. In all three the menstrual flow had been present for from one to two days before a physician was called, suggesting that the congestion associated with the period might have played a part in making the process, once initiated, irreversible. All three patients showed an advanced type of disorder due to the fact that a physician was not called

for from twelve to twenty-four hours after severe pain had started. Had there not been a menstrual flow there is no question but that these patients would have come to operation earlier since these were all city dwellers and had consulted physicians regularly for other complaints. The temperature was not over 101°F. but there was a marked leukocytosis with a high polymorphonuclear count as well as definite signs of an acute condition of the abdomen in all.

In the first and second patients the differential diagnosis was easy; the third patient presented a complicated picture due to her age and the severe pelvic signs. A differential diagnosis between infected ectopic pregnancy and pelvic inflammation could not be made positively. The writer has had one case of infected ectopic pregnancy previously reported<sup>3</sup> in which a diagnosis was made by cul-de-sac puncture. A review of cases at the Binghamton City Hospital at that time demonstrated that of sixty-two cases of ectopic pregnancy, twenty-three or 37.1 per cent had an elevation of temperature ranging from 99 to 102°F. The possibility of instrumentation always had to be considered in these patients. In our third patient previous sterility suggested the possibility of an ectopic pregnancy. The signs of infection were so severe, however, that cul-de-sac puncture was not done and the tendency was to consider it a probable pelvic inflammation.

The differential diagnosis between appendicitis and pelvic inflammation may be difficult and at times impossible. The presence of a purulent discharge from the urethra and the cervix plus the signs of diffuse pelvic disturbance could not be used as differential points in these cases because of the menstrual flow. The white count tended to differentiate a gonorrheal inflammation but corresponded in general to that expected in a streptococcic infection.

Pelvic appendicitis is difficult to diagnose

<sup>3</sup> SNEIERSON, H. Infected ectopic pregnancy. *M. Times*, 68: 107, 1940.

and sometimes may be diagnosed only after the condition has gone on to suppuration and abscess formation. The localization of right lower quadrant pain with muscle spasm may not be present; and if there is any vaginal discharge, pelvic peritonitis will undoubtedly be considered first. If the condition is seen sufficiently early and the process is limited to the right side, the diagnosis can be made with certainty. Graham<sup>4</sup> states that it may not be possible to differentiate the two in all cases.

Curtis<sup>1</sup> defines menstruation as a "bloody uterine discharge associated with necrosis of the uterine mucosa, normally recurring throughout the child-bearing period, except in the event of pregnancy, at relatively regular intervals of  $3\frac{1}{2}$  to 5 weeks, usually with a duration of from 2 to 5 days." It is evident, therefore, that a woman flows anywhere from one-tenth to one-eighth of the child-bearing period. In the ordinary course of events one would expect 10 per

cent of operations for acute appendicitis to occur at this time in these patients. This evidently is not true, at least as far as operative reports are concerned, and yet immediate operation, as a rule, is practiced throughout this country whenever the diagnosis is made.

During 1946 through 1948 inclusive approximately 800 women patients were operated upon for appendicitis at the Binghamton City Hospital, of which only the three reported occurred during menstruation. This low incidence conflicts with the expected number suggested by Hollosi and suggests that menstruation is a coincidental finding only.

The presence of the pelvic type of appendix in each instance is important and bears emphasizing. We agree with Hollosi that given an acute attack in a pelvic appendix, the presence of acute congestion of the pelvic organs during menstruation will aggravate the inflammatory changes and tend to make them irreversible.

HYMAN SNEIERSON, M.D.



<sup>4</sup> GRAHAM, E. *Surgical Diagnosis*. Philadelphia, 1930. W. B. Saunders Co.

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# Original Articles

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## SURGERY FOR THE PREVENTION OF PULMONARY EMBOLISM\*

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PULMONARY embolism resulting in sudden death may now be prevented in many patients who in previous years were destined to succumb to this unfortunate condition without any rational therapy. For a long time it was believed that the hazard of death from pulmonary embolism was one which of necessity had to be borne by the patient who underwent major surgery. Surgeons and internists usually believed that little could be done to reduce the possibility of this complication. In recent years this attitude has been replaced by a widespread interest in seeking to diagnose thrombotic disease when it first develops and by appropriate methods of treatment to prevent the complication of pulmonary embolism. The current attitude toward the treatment of this condition and the lives saved as a result of this newer concept have resulted from a better understanding of the underlying pathologic conditions which cause the development of thrombi in the venous system.

In former years pulmonary embolism was usually considered a complication of surgery. It is now generally recognized that many patients who have never undergone surgery are at times troubled with venous thromboembolic disease and that these patients may suffer from a fatal attack of pulmonary embolism. Internists now correctly attribute certain chest complications as being the result of pulmonary emboli in bedridden patients who have undergone surgery. Attention is also being called to the presence of the early signs of venous

thrombosis in the extremities. Adequate therapy saves many patients from the unfortunate outcome which in previous years occurred.

The majority of venous clots have their beginning in the deep veins of the lower leg and foot.<sup>1-4</sup> The thrombosis which begins in the plantar veins or in the deep veins of the leg may gradually extend to higher levels by direct propagation. In other instances such a clot may be dislodged before extensive propagation has taken place. In such instances fatal pulmonary embolism may occur and at autopsy the origin of the fatal embolus will not be found unless the veins of the lower leg are examined.

Thrombotic venous disease is usually divided into two types, phlebothrombosis and thrombophlebitis. Phlebothrombosis, a term which Ochsner and DeBakey popularized and which is referred to by Homans as the quiet bland type of intravascular clotting, is more likely to be followed by pulmonary embolism than is thrombophlebitis.<sup>5</sup> In my opinion it is rational to believe that phlebothrombosis and thrombophlebitis are in reality extreme variations of the same general process.<sup>6</sup> In thrombophlebitis there is a definite inflammatory reaction present in the wall of the vein. This inflammatory reaction increases the probability of the clot becoming adherent to the vein wall; consequently pulmonary embolism is less likely to occur in patients with thrombophlebitis than in patients with phlebothrombosis. It is also

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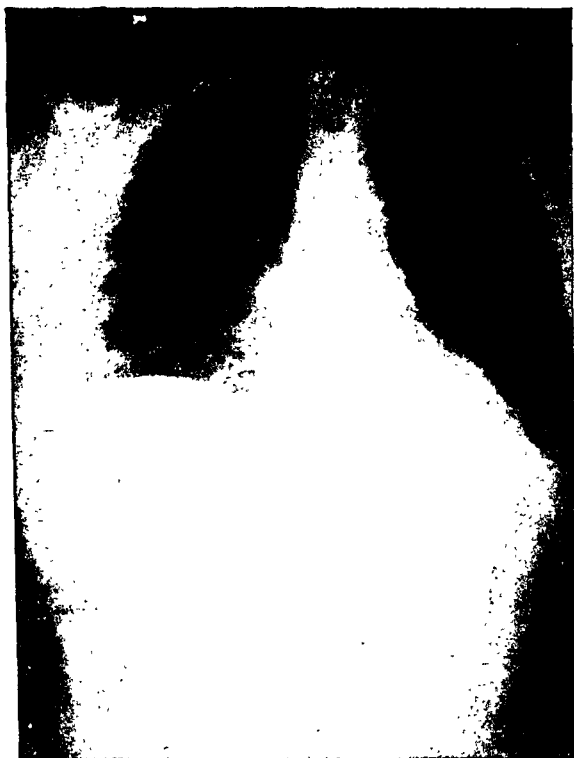


FIG. 1. Case 1; film of chest shows wedge-shaped area of increased density at lateral border of right lower lung field.

true that patients with thrombophlebitis have more systemic symptoms such as fever, leukocytosis, malaise and pain. Even though these two terms represent extreme variations of the same process, I believe that it is very useful to designate cases of thrombotic venous disease as belonging to one of the two types. The reason for this is readily apparent when one remembers that thrombophlebitis is infrequently followed by pulmonary embolism whereas phlebotrombosis or the bland type of thrombosis is not infrequently followed by pulmonary embolism. Because of the difference in the course of the conditions mentioned the treatment is decidedly different.

#### ETIOLOGY

Many factors influence the development of venous thrombosis. In some cases it is impossible to determine the exact etiology. Venous thrombosis in general is favored by anything which produces a slowing of the circulation, a change in the vessel wall or an increase in the coagulability of the blood.

Perhaps the most important of these factors is that of the retardation of the circulation. It is readily apparent that any patient who is kept in bed for a period of time is more apt to have thrombi form in veins because of the retardation of the venous circulation which accompanies the lack of muscular effort.

The posture of the patient therefore becomes much more important than was formerly recognized. Pillows placed beneath the knees may make the patient much more comfortable; however, they certainly tend to cause stasis of the venous blood in the lower leg and therefore this comfortable posture may be dangerous. It should be remembered in practicing early ambulation that the patient who simply walks to a chair and sits in the chair for twenty or thirty minutes with the knees flexed and trunk flexed is not carrying out a procedure which will decrease the incidence of venous thrombosis and of secondary pulmonary embolism. Bandages which are applied too tightly may interfere with the venous return and may thereby contribute toward the formation of thrombosis in the deep veins.

Infection in or about a vein and trauma to a vein will tend to favor the development of thrombosis.

Dehydration favors intravascular clotting because of the fact that in such cases the coagulability of the blood is apt to be increased. The increase in the platelet count which usually follows major surgery also is a factor which favors the development of an increase in tendency toward intravascular clotting.

#### DIAGNOSIS OF VENOUS THROMBOTIC DISEASE

The diagnosis of thrombophlebitis is usually easy. Pain is produced by inflammatory reaction in the vein wall. This inflammation in the vein wall likewise produces an associated spasm of the arteries of the extremities and arterial spasm increases the pain. Fever is usually present. Examination reveals the presence of tenderness along the course of the vein and in many

instances a clot can be felt when the vein is palpated.

By contrast the patient who has phlebothrombosis may show few positive signs on

may be a very slight cyanosis. Tenderness may be present over the soles of the feet and pressure over the calf muscles may likewise demonstrate tenderness.

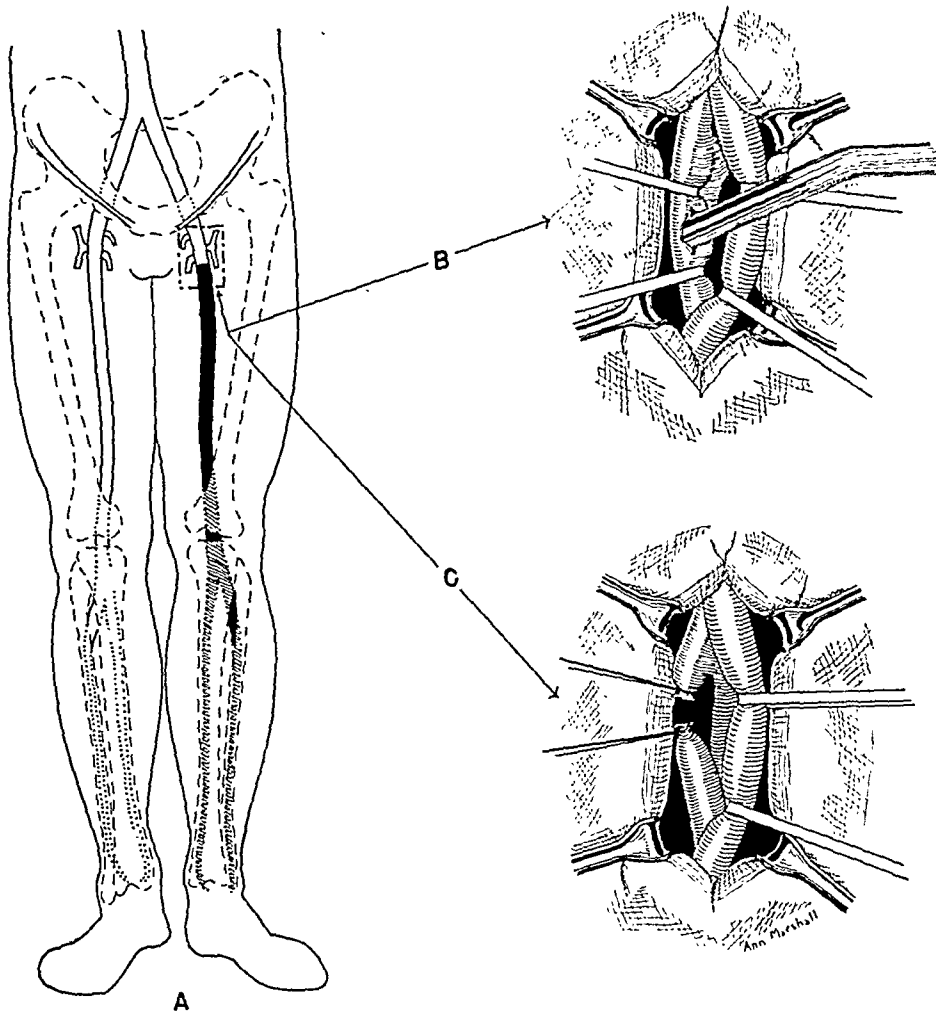


FIG. 2. Case 1. A, drawing illustrates extent of the venous clot extending up to just below the profunda branch of the femoral vein. B and C, insets demonstrate removal of soft thrombus with suction tube and ligation of vein.

examination. Usually there is a very slight increase in the pulse rate and likewise only a slight elevation of the temperature above normal. The patients with phlebothrombosis are apt to complain of some tenderness or discomfort in the calf of the leg. Dorsi flexion of the foot produces pain in the calf muscle group.

This finding which was described by Homans is usually referred to as Homans' sign. Inspection in such instances may reveal a very slight increase in the size of the veins of the affected extremity. There also

#### THERAPY FOR THROMBOPHLEBITIS

Elevation of the extremity without constriction below the knee is indicated. The local application of heat is beneficial. In the early course of the disease sympathetic nerve block with procaine helps to overcome the associated arterial spasm and thereby tends to decrease the pain. In some cases tetraethylammonium given intramuscularly to block the autonomic nerves is a helpful procedure. In such cases most surgeons now prefer to allow the patient to move the extremity as he desires; in fact,



FIG. 3. Case 11; anteroposterior and lateral views of chest demonstrating large pulmonary infarct secondary to embolus which originated in right femoral vein.

movement of the extremity is even encouraged in many instances.

In thrombophlebitis the clot is more likely to become adherent to the vein wall; however, it is true that in certain instances such a clot may break off and produce a fatal embolus.<sup>7,8</sup> In other instances showers of bacteria may be thrown off from an infected clot which is present in a patient with thrombophlebitis. Because of this in certain selected cases of thrombophlebitis vein ligation above the site of the thrombus is indicated. It is difficult to outline rigid rules regarding when venous ligation should be done in cases of thrombophlebitis. In general, however, we believe that a patient with thrombophlebitis in whom the process is spreading very rapidly should have a proximal vein ligation. It is also believed that patients who are having showers of bacterial emboli from an infected thrombus secondary to thrombophlebitis should have venous ligation.

#### THERAPY FOR PHLEBOTHROMBOSIS

Fatal pulmonary embolism may be prevented in many instances by the recogni-

tion in the early stages of venous thrombotic disease and by following such recognition with appropriate therapy. Appropriate vein ligation in the patient with phlebothrombosis in our opinion is the best method to prevent fatal pulmonary embolism. In certain instances it is possible to make a diagnosis of phlebothrombosis when the clot extends only to the knee. In such instances the superficial femoral vein is opened, divided and ligated below the level of the profunda vein. If the bland thrombus has extended to the level of the profunda or above and if it can be aspirated successfully so an adequate back flow of blood is obtained, one should still perform the venous ligation below the level of the profunda vein. When the superficial femoral vein can be ligated below the profunda, the patient is not apt to be troubled with post-operative edema of the extremity. On the other hand, in some instances the profunda itself is filled with clots and in such instances it will be necessary to ligate the common femoral vein above the profunda. The utilization of an elastic bandage for a period of several weeks to a few months

following operation is very beneficial in decreasing permanent edema of the extremity. It should be remembered that the edema which follows the treatment of such disease is associated with and, to a great extent, is dependent upon the amount of intravascular clotting which existed before the operation was done. It is common knowledge that patients who have had recurrent thrombophlebitis are apt to have chronic edema of the extremity. In many instances it is possible to aspirate a soft thrombus from the iliac vein through the opening in the superficial femoral vessel. In some other instances it is impossible to remove such a clot by this method. In such instances if the patient's general condition permits, we believe that it is safer and technically easier to ligate the vena cava above the bifurcation rather than to attempt a bilateral iliac ligation.<sup>9,10</sup>

#### ANTICOAGULANT THERAPY

Heparin and Dicumarol have been used by many in the treatment of the condition being discussed.<sup>11-17</sup> It is certainly true that these agents decrease the coagulability of the blood. It is also true that neither heparin nor Dicumarol have any tendency to dissolve a thrombus which is already present in a vessel. These agents simply make propagation of such a clot less likely to occur and do not give any assurance that the clot which is already present will not break off and cause fatal embolism. We have treated a limited number of patients with anticoagulant therapy. However, we much prefer to treat such patients by appropriate vein ligation since we believe this procedure gives greater security against fatal pulmonary embolism and likewise it is less likely to be followed by untoward complications.

#### CASE REPORTS

**CASE 1.** G. R. E., a white female, age sixty, was seen in consultation at the Willis C. Campbell Orthopedic Clinic on December 12, 1948. The patient had been in bed for three weeks while receiving treatment for a chronic back complaint. During this time the patient suffered



FIG. 4. Case 111; film reveals congestion of both lung bases and the presence of fluid in the costophrenic angles.

fered a sudden attack of severe chest pain with associated hemoptysis. There was a definite sensation of impending doom. The past history revealed several attacks of thrombophlebitis in the right leg occurring over a period of several years. Examination of the chest revealed a friction rub near the base of the right lung. A chest x-ray demonstrated a wedged-shaped area of increased density in the right lung field characteristic of a pulmonary infarct. (Fig. 1.) Examination of the right lower extremity showed Homans' sign to be positive (pain in the calf resulting from dorsi flexion of the foot). There was a slight distention of the veins of the right foot.

Femoral vein exploration was first done on the right side. The vein was opened just below the site of the profunda branch. A large soft clot was found in the superficial femoral extending to a point just below the profunda. A portion of the thrombus approximately 4 inches long was removed with the suction tube. (Fig. 2.) A normal back bleeding occurred from above and the profunda did not appear to be involved. The vein was divided and transfixed at the point where it had been opened.

Because of the possibility of a silent thrombus in the left superficial femoral vein, the left side was opened, divided and ligated. No clot was found on the left side. Elastic bandages

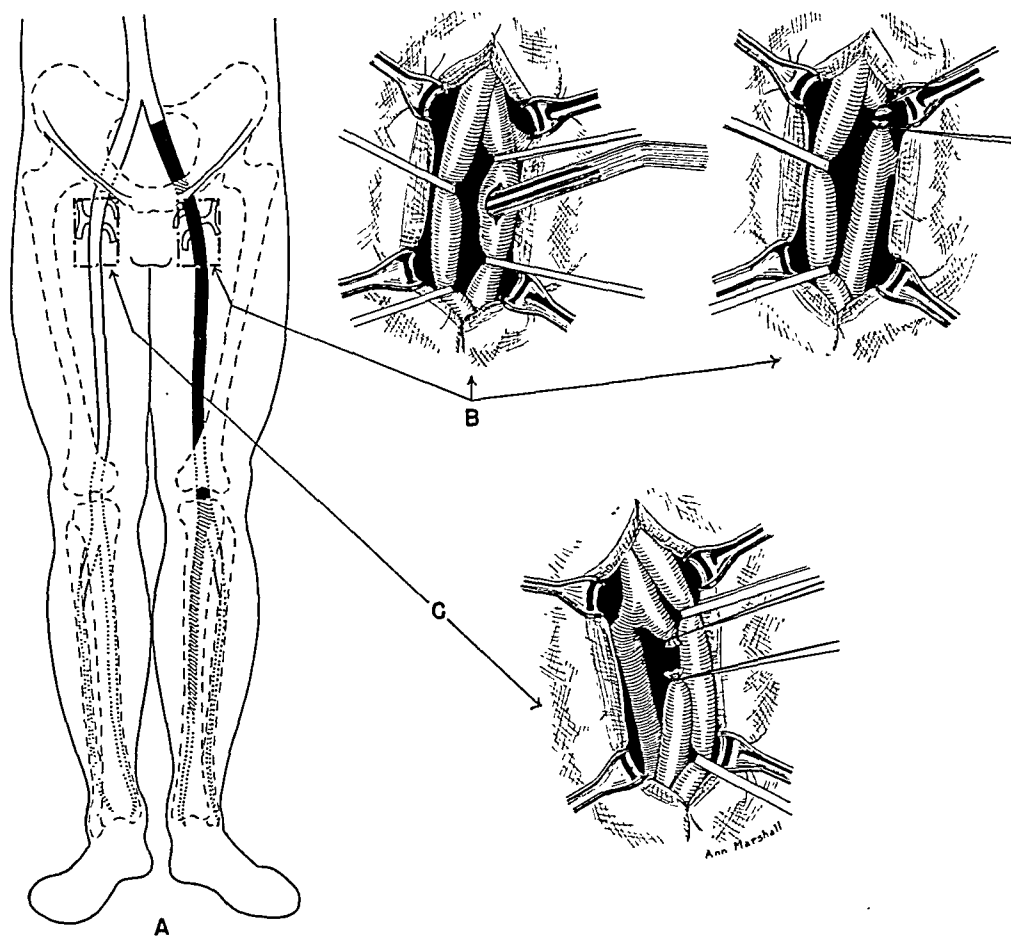


FIG. 5. Case III. A, thrombus extended well above profunda branch of femoral into the common iliac vein; B and C, clot removed by suction and vein divided above the profunda branch.



FIG. 6. Case IV; films made on admission to hospital before and after thoracentesis. Initial film reveals massive hydrothorax; film after the chest aspiration reveals massive infarct of right lung.

were used on the extremities for several weeks. There have been no recurrences of pulmonary infarction and no residual swelling of the extremities.

CASE II. W. H. C., a male, age thirty-five, entered the Baptist Memorial Hospital on the

saphenous was divided above the thrombus. The superficial femoral vein was opened and divided below the profunda branch on both the right and left side. No thrombus was found in either femoral vein. There has been no further pulmonary difficulty. The right leg remained

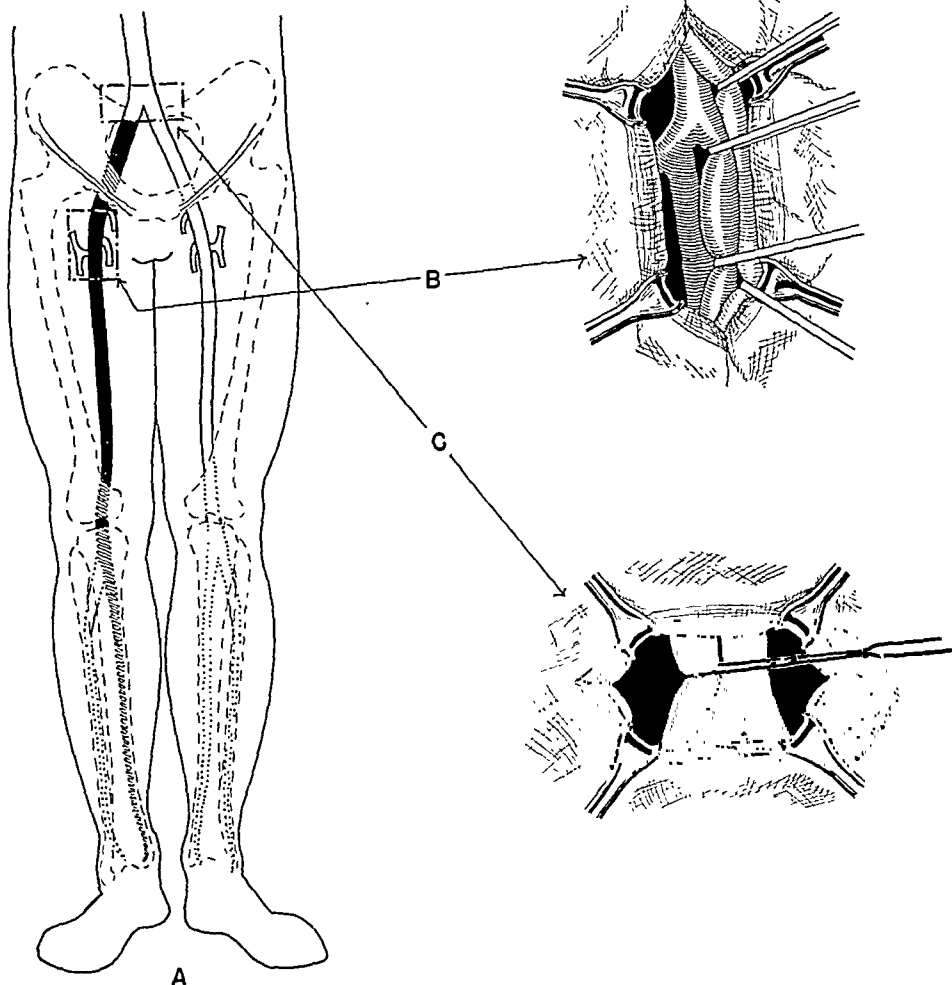


FIG. 7. Case IV. A, right femoral vein contained adherent thrombus; B and C, ligation of vena cava accomplished through transverse incision at level of umbilicus.

chest service of Dr. Duane Carr May 11, 1948, because of pain in the right chest, hemoptysis and fever. The history revealed that the patient had suffered from recurrent attacks of thrombophlebitis in the right leg over a period of years. Examination of the chest revealed extensive abnormal findings in the right side. A film demonstrated a large wedge-shaped lesion interpreted as a large pulmonary infarct. (Fig. 3.) There was tenderness to pressure over the right calf muscle and dorsi flexion of the right foot produced pain.

A thrombus was found in the right saphenous vein extending to a point 1 inch below the junction of the saphenous and femoral veins. The

slightly swollen for a period of three months necessitating the use of elastic bandages.

*Comment.* Pulmonary emboli occur more frequently in patients with phlebothrombosis and in those with frank thrombophlebitis. This case emphasizes that these conditions are probably only variations of the same process. Varicose saphenous veins are rarely the site of thrombi producing embolism but this case illustrates such an instance.

CASE III. J. M., a male, age forty-five, entered the hospital on the medical service of

Dr. Phil B. Bleecker, October 7, 1947. The patient had suffered from repeated bouts of chest pain with associated fever and cough. Chest examination revealed a friction rub over the left chest laterally and anteriorly. Films of the chest demonstrated congestion at both bases and a slight amount of fluid was seen in

a period of years the patient had suffered from recurrent attacks of thrombophlebitis in the right leg. An extensive pleural effusion was found in the right side. After thoracentesis an area of increased density was found which was interpreted as a massive pulmonary infarct of the right lower lobe. (Fig. 6.)

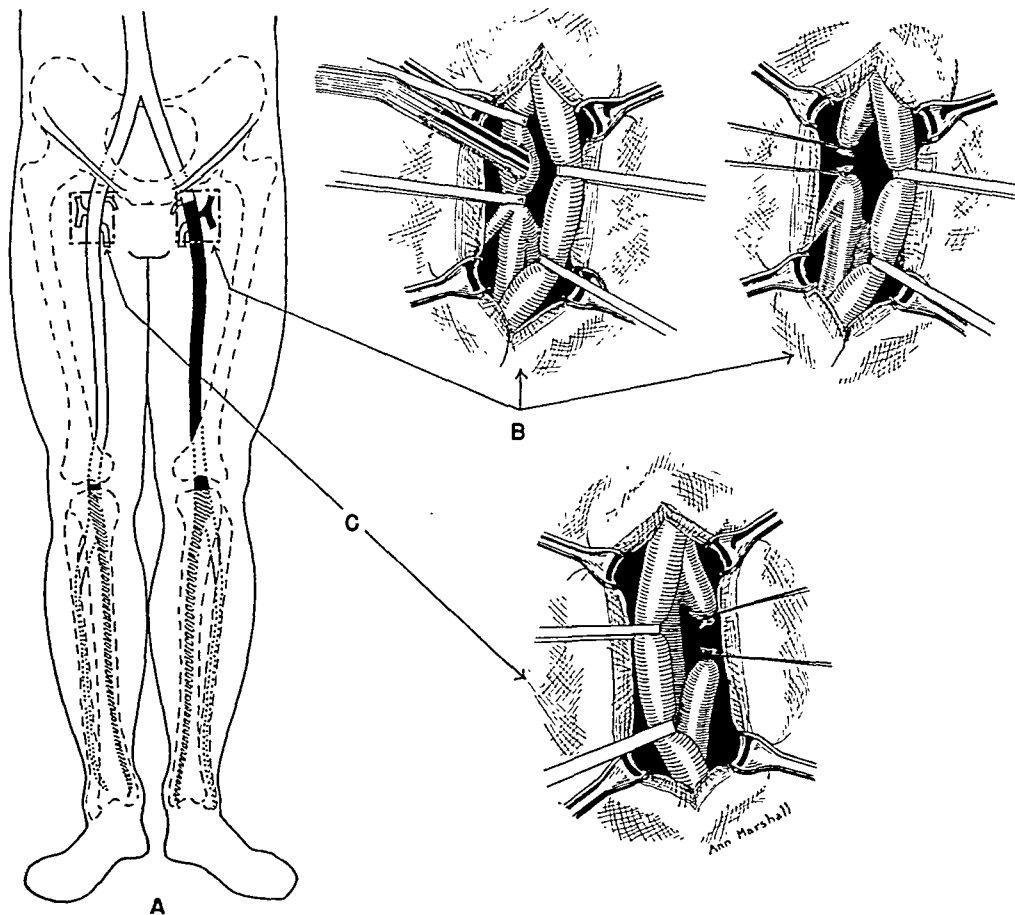


FIG. 8. Case v. A, B and C, soft thrombus aspirated from left iliac vein via opening in left femoral; profunda branch filled with thrombus; ligation of femoral vein above profunda branch.

the costophrenic angles. (Fig. 4.) Several days after admission to the hospital the patient developed signs of phlebothrombosis of the left leg. At operation a soft thrombus was aspirated from the left femoral vein. The profunda branch was found to be involved and the vein was divided above this junction. (Fig. 5.) No clot was found when the right vein was explored. There have been no further attacks of chest pain, fever or cough.

CASE IV. P. R., a white male, age forty-nine, entered the hospital October 18, 1947, on the chest service of Dr. Duane Carr. The chief complaint was that of dyspnea and fever. Over

At operation the right femoral vein was explored. It was found to be filled by a thrombus which could not be removed early. The thrombus extended well up into the right iliac vein. (Fig. 7.) The vena cava was exposed and ligated just above its bifurcation with a strip of umbilical tape. The superior limit of the thrombus was seen in the right iliac vein below its junction with the vena cava. Most of the extremity edema subsided after two months. After eight months there was only a very slight amount of swelling which was present in the right ankle.

*Comment.* This probably is an example of a bland thrombus being superimposed upon an old organized clot which originated from frank thrombophlebitis.

The left femoral vein was opened and immediately a soft clot 2 inches long extruded itself. With the suction tube a thrombus which appeared to be a cast of the left iliac vein was

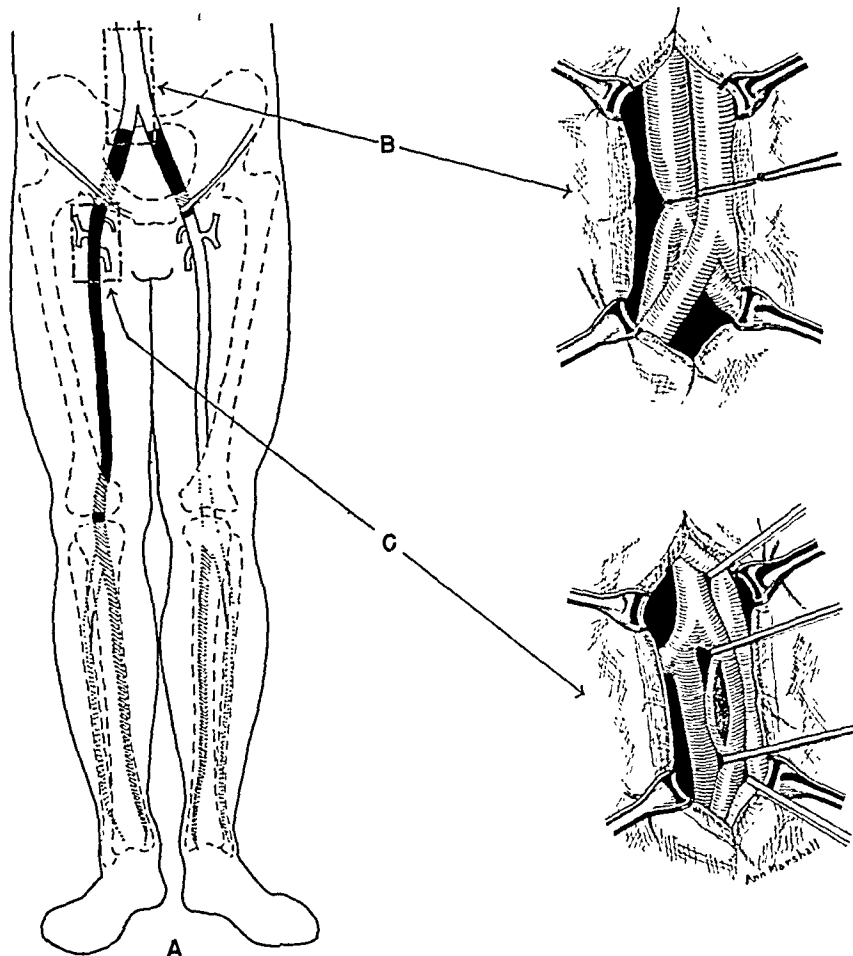


FIG. 9. Case VI. A, B and C, right femoral vein opened as shown in lower inset (c). Adherent thrombus could not be removed; longitudinal transabdominal incision used to expose vena cava; thrombi found in both common iliac veins; ligation of vena cava performed above bifurcation of vena cava.

**CASE V.** C. W. R., a white male, age sixty-five, was admitted to the hospital on January, 22, 1948, on the orthopedic service of Drs. Higley and Ray because of pain, swelling and tenderness of the left leg. Approximately three weeks prior to this admission patient had been struck by an automobile and had sustained a fracture of the right fibula and shoulder injury. On January 21, 1948, the patient noticed pain, swelling and tenderness of the left leg. One day later the tenderness and swelling extended into the left thigh. Homans' sign was positive. The left thigh was tender along the course of the left femoral vein. This appeared to be a rapidly progressive thrombotic process involving the left femoral vein.

removed. The femoral vein was ligated above the profunda. The right femoral vein was explored and ligated below the profunda branch. (Fig. 8.) Convalescence was uneventful.

**CASE VI.** W. L. B., a white male, age sixty-five, was admitted to the hospital November 29, 1947. On admission the patient complained of pain beneath the right lower ribs anteriorly. He had been hospitalized previously because of thrombotic venous disease of the right leg but had refused treatment. A diagnosis of phlebotrombosis of the right lower extremity was made.

At operation it was impossible to remove the firm clot from the right femoral vein. The thrombus obviously extended into the right



iliac vein. The abdomen was opened and the vena cava explored. Thrombi were found extending into both common iliac veins. The vena cava was ligated just above its bifurcation. (Fig. 9.) The postoperative course was stormy and it was necessary to do a secondary closure of the abdominal wound because of wound disruption. However, the patient eventually made a satisfactory recovery. Three months after operation there was very little swelling of the extremities.

#### SUMMARY AND CONCLUSIONS

1. Some of the etiologic and pathologic features of thromboembolic venous disease have been reviewed.

2. Phlebothrombosis and thrombophlebitis are believed to be extreme variations of the same abnormal process.

3. Fatal embolism is less likely to occur in frank thrombophlebitis than in phlebothrombosis.

4. Phlebothrombosis when definitely diagnosed is probably best treated by appropriate vein ligation.

5. Acute thrombophlebitis usually is best treated by sympathetic block, elevation of the extremity, motion without weight bearing and the use of heat in cases in which it makes the patient more comfortable.

6. Anticoagulant therapy expertly used will definitely decrease the incidence of pulmonary embolism. There are certain inherent dangers associated with use of this form of therapy.

7. Conscientious use of measures designed to prevent venous thrombosis will result in the saving of many lives.

8. Illustrative cases are cited which emphasize the variety of patients that may suffer from thromboembolic venous disease.

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# PHLEBOTHROMBOSIS OF THE LOWER EXTREMITIES\*

## CRITICAL FACTORS IN EVALUATING THE SITES OF FEMORAL VEIN SECTION

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DEEP phlebothrombosis of the lower extremities continues to be a problem far reaching in its complications and sequelae. Its importance is readily indicated by the fact that fatal embolism following phlebothrombosis occurs in 3 to 6 per cent of cases.<sup>1</sup> Further, 11 to 18 per cent of patients who survive one pulmonary embolus experience a subsequent one which is fatal.<sup>2,3</sup> Chronic lymphedema is another serious problem not to be taken lightly. It is evident that the most desirable treatment is that which will result in a minimum of swelling, reduce morbidity and avoid mortality. In spite of the voluminous literature now listed on the subject some misunderstanding apparently still exists as to the indications for femoral vein section and especially the levels for section.

Among other things this paper is especially concerned with evaluating the sites of femoral vein section. In a discussion of the factors concerned a consideration of the physical effects of ligation at different levels is important. Equally important moreover is an analysis and review of many problems peculiar to thromboembolic disease. Based on the aforementioned an interpretation of management should comprehend a consideration of the following problems and factors: (1) pathogenesis of thrombosis in the lower extremities; (2) the importance of adequate physical examination in the diagnosis of origin and progression of the thrombosis; (3) evaluation of the end results of femoral section at different levels as concerns postoperative edema and sequelae, namely, phlebitic ulcer;

(4) postoperative morbidity and mortality; (5) results of femoral section at different levels with and without anticoagulants; (6) femoral section in acute femoro-iliac thrombophlebitis and its relation to embolization; (7) the incidence of pulmonary infarction after section at different levels; (8) femoral section when contraindications to anticoagulants exist, namely, bleeding tendency, arteriosclerosis, hepatic disease, hypertension, recent gastrointestinal bleeding, prolonged initial prothrombin time and hyperthyroidism; (9) the status of venography in determining level of femoral vein section; and (10) the role and effectiveness of prophylaxis in thromboembolism.

It is not our purpose at this time to consider the controversy of ligation versus anticoagulant treatment. It is believed that a proper evaluation of the different types of treatment will relegate them to their proper sphere regardless of the enthusiasm of their advocates. We do not believe that anticoagulant therapy and ligation should be considered separately as anticoagulants may be used at times whether operation is carried out or not; this is our practice.

Present mature judgment now tends toward the conclusion that both surgical and medical treatment have comparably reduced the fatalities due to initial and subsequent pulmonary emboli. Although admittedly not the complete solution to the problem, either method is undoubtedly preferable to the "do nothing" or "expectant" school of treatment. One method or the other, or both, should be used in every patient if that individual is to receive treat-

\* From the Department of Surgery, Barnes Veterans Hospital, Vancouver, Wash. Sponsored by the Veterans Administration and published with approval of the Chief Medical Director. The statements and conclusions published by the author are the result of his own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

ment commensurate with present day medical knowledge.

It is probable that we know the proper therapeutic measures but in the light of our present knowledge are still unable to select critically the right method for the right patient.

It is now well established and generally recognized that thrombosis of the lower extremities most often begins in the plantar and calf veins, less frequently in the veins of the abductor muscles and rarely in the femoral and lower iliac veins as was previously supposed.<sup>4,5</sup> Hunter et al. and Frykholm,<sup>6</sup> among others, have graphically demonstrated this in their pathologic studies. While the aforementioned veins are the principal sites of origins of thrombi, it is well to remember that they can originate in other primary sites.

As one understands the course that the disease may follow the rationale for the different types of vein interruption becomes clear. Homans<sup>7</sup> has described the course that phlebothrombosis in the lower extremities may take as follows: (1) The thrombus may heal without ever progressing upward above the knee or causing pulmonary embolism. (2) It might develop into a femoro-iliac thrombosis (phlegmasia alba dolens) in which case it was very unlikely to cause pulmonary embolism? (3) It might form a soft propagating thrombus seriously threatening pulmonary embolism.

Based on a study of forty-two cases it is believed that the different stages of phlebothrombosis can be divided into five stages as an aid to clinical management as follows:

*Stage 1.* Here the thrombus is present most frequently in the muscles of the calves and less commonly in the plantar and adductor muscles and may have progressed up to but not into the popliteal veins. *Stage 11.* The thrombosis has progressed into the popliteal and lower femoral veins. At this point it is generally found as a propagating floating mass which is not adherent to or obstructing the femoral veins. *Stage 111.* Here the thrombus has further progressed as a loose, propagating

mass which may only partially obstruct the femoral vein and may or may not be adherent to it. It has generally reached the level of the common femoral vein and there may or may not be concomitant clot present in the profundus. *Stage iv.* The process has progressed so that the thrombus extends well up into the iliac vein. At this point it may be adherent to the intimal surface of the vein and is generally non-obstructing. The proximal end of the thrombus may be detached easily. An associated thrombosis may or may not be present in the deep femoral system. *Stage v.* Beyond this point the clot becomes strongly adherent to the entire femoral vein and now fully obstructs it and the internal iliac vein. An inflammatory reaction develops. This process is accompanied by lymphangitis and the end result is an acute femoro-iliac thrombophlebitis or so-called phlegmasia alba dolens.

Unquestionably, emboli can occur during any one of the aforementioned stages. In *Stage 1* if an embolus is detached, it generally will be very small because of the small caliber of the veins encountered in the muscles involved. There may be frequent showers of small emboli, most often non-fatal. In *Stage 11* there is a greater threat of pulmonary embolus. Here inasmuch as the thrombus has reached the larger-sized vessels, the popliteal and the lower femoral, a much larger-sized embolus can be detached. This embolus, of course, may or may not be fatal. In *Stages 111* and *iv* pulmonary embolism is seriously threatened at all times. Here there is a long, loosely attached, propagating thrombus which can detach at any time an embolus large enough to be instantly fatal. This is probably the most dangerous stage in the progression of the thrombosis. In *Stage v*, or femoro-iliac thrombophlebitis, embolism occurs infrequently. The reason for this is easily understood inasmuch as there is an intense inflammatory reaction associated with the process of clotting. Here the thrombus is usually quite adherent to the intimal wall. However, contrary

to opinion, one may not be completely assured that embolism cannot occur when the process has developed into a true milk-leg for emboli can be and not infrequently are detached from such a thrombus. Hence, while the frequency of detached emboli in Stage v is undoubtedly less than in the preceding stages, it is definitely a factor to be reckoned with in treatment.

This origin and propagation by stages of a thrombus of the lower extremities to a full blown femoro-iliac thrombophlebitis has its evidence in the following facts. First, Bauer<sup>8</sup> has shown and traced by venographic studies the development of a full fledged obstructive phlegmasia alba dolens from its source in the deep veins of the legs. Second, at times a history of pulmonary infarction can be secured indicating that a soft, non-obstructive thrombosis has preceded by some time the appearance of the typical edema and discomfort of a femoro-iliac thrombophlebitis. Third, there are observations such as that cited by Conner<sup>9</sup> based on experiences with typhoid fever of very suggestive early signs in the form of pain and tenderness in the toes, feet and calves before the unmistakable swelling of phlebitis becomes apparent. Finally, the graphic studies of Hunter and his associates show the presence of clot at different levels at autopsy and are additional evidence for the origin and progression of the thrombus as above described. Bauer and others have estimated that about 90 per cent of iliofemoral thrombophlebitis is of such origin and about 10 per cent begin elsewhere in the groin or pelvis.

The essential difference between phlegmasia alba dolens and an advanced phlebothrombosis lies in the unexplained inflammatory action about the artery and vein in the femoral and iliac regions of the thrombus. Only when the occluded vein is completely obstructed by a solid thrombus does this reaction set in giving rise to the edematous limb often painful, usually marked by tenderness over the affected vessels, together with some perivascular inflammatory thickening in the groin. The

reaction may be minimal or take the form of an acute non-suppurative exudate. The exudate involves the nearby nervous and lymphatic structures as well as the artery and vein.<sup>10</sup> This certainly offers an explanation of the occasional viscous local spasmotic constriction of the artery and the irritating impulses which appear to travel centrally from the region involved, calling forth reflexly, by way of the sympathetic nervous system, the peripheral vasoconstrictions which are to be recognized as a major cause for the edema and discomfort of acute femoro-iliac thrombophlebitis.

Based on this description of the origin and propagation of a thrombus in the lower extremities, we believe that one may with a reasonable degree of accuracy diagnose the level of the thrombosis based on clinical signs and findings. The physical signs and findings in the different stages will now be described together with the underlying basis for the appearance of some of these signs. It is with these factors in mind that one can proceed to manage adequately the various cases of phlebothrombosis which he encounters.

At the onset of Stage 1 (phlebothrombosis of the lower extremities) it is quite likely that there will be no symptoms whatever. The only way of discovering an early phlebothrombosis in the leg is by routine palpation of the calf, adductor muscles and the plantar aspect of the foot to ascertain tenderness. In our series the very first complaint offered by the patient was that of pain which occurred in 40 per cent of the cases. In a group of 200 cases studied Kleinsasser<sup>11</sup> reported pain as being the first symptom in 34.8 per cent of the cases. Other early findings that may occur in this stage of phlebothrombosis are an elevation of temperature and tachycardia which will be seen in a small per cent of cases. At this stage a positive Homans' sign can generally be elicited. We have observed that if one routinely palpates the calves of post-operative patients, tenderness will often be elicited before a Homans' sign appears. When Homans' sign appears, the process

is reasonably well along and phlebothrombosis is well established. Pulmonary embolism can and does occur as an initial finding in early phlebothrombosis when there are few or no leg symptoms. As a matter of fact, a certain percentage of patients will be admitted to the hospital with findings of pulmonary embolism. Examination will disclose the presence of phlebothrombosis of the lower extremities. Pulmonary embolus under these circumstances will generally be of the sub-lethal variety because of the small size of the vessels in which the clot originated. In this stage of phlebothrombosis the single most important finding is calf tenderness. This can be elicited very early in the course of the disease by repeated examination of the probable source of origin of the thrombi. If this is done, phlebothrombosis will be diagnosed at the stage which may be termed the "golden period" of treatment.

In Stage II with an advancing tibial phlebothrombosis, the thrombus may have reached the level of the popliteal or lower femoral vein. The findings usually will be a repetition of those of the previous stage and probably the initial complaint of the patient will be pain in the calf. Here the process is well established and it has progressed beyond the stage of original tenderness elicited by calf palpation. Elevation of temperature, tachycardia and sedimentation rate elevation are frequently observed. A positive Homans' sign is usually present. As in the earlier stage, pulmonary infarction not infrequently may be the presenting complaint. Usually there are no evidences of obstructive phenomena. There is a good probability of a fair-sized embolus being detached. The incidence of pulmonary infarction is greater here than in the previous stage. In addition there may or may not be a few dilated leg veins. Similarly there may or may not be mild cyanosis of the lower extremity in the dependent position. Cyanosis usually is not evident in the recumbent position.

In Stages III and IV all the previous findings will be apparent. In addition dilated

veins will be especially noted, particularly on the anterior aspect of the leg. This is due to the progression of the thrombus with partial occlusion of the main deep vein and resultant compensatory dilatation of the superficial leg veins as a collateral circulation. Pratt<sup>12</sup> has called attention to certain dilated veins that he has observed repeatedly. He states this consists of the dilatation of three small superficial veins directly over the tibia, running into one medial branch in phlebothrombosis. He believes that with occlusion of the main vein in the popliteal space these small veins dilate because they are the closest collateral vessels, and this sign has been so constant in his experience that he now considers it of definite diagnostic value. This in general is in agreement with our observations; and when dilated veins are noted as described heretofore, we believe that they have great significance. Under these circumstances a thrombosis probably exists which is well along in the course of the femoral vein which is propagating, is loosely attached and is seriously threatening embolism. This is a very dangerous state of phlebothrombosis. The next sign usually found in this stage is edema of the lower extremities, particularly on dependency. The explanation for this is obvious for as the clot advances a greater degree of occlusion of the femoral vessel occurs with the consequent inadequate circulation and resultant venostasis and edema. As the clot progresses the edema becomes more advanced. On the basis of grading of one to four in this stage of phlebothrombosis, the degree of edema will generally be one or two plus. In our series of cases edema was noted in this stage of phlebothrombosis in 87 per cent of the cases. Cyanosis of the lower extremities, particularly on assuming the erect position, is usually more evident. The pathogenesis or origin of the cyanosis is similar to that for the previous finding. In a small percentage of cases at this stage (8 per cent in our group) there may be coldness of the extremities due to associated arteriospasm and with it sweating,

tingling of the legs, rarely numbness and redness. Occasionally in this stage thrombosed superficial varicosities will be noted in the leg which are occasionally a heralding sign of associated deep phlebothrombosis. These are usually inflamed and are always tender to touch. In this stage of phlebothrombosis the percentage of patients that enter with signs of pulmonary infarction will be obviously greater. This represented 28 per cent in our series. Some of the patients in addition may complain of a sense of impending disaster.

In summary, the diagnosis of phlebothrombosis of the lower extremities may be based on the following symptoms approximately in the order of their frequency: (1) tenderness, (2) pain, (3) mild swelling of the leg, (4) dilatation of veins of the leg, (5) increased pulse and temperature, (6) cyanosis of the leg in the standing position, (7) pulmonary embolism and (8) sense of impending disaster.

In Stage v the thrombus has progressed up above the femoro-iliac junction and entered the iliac veins. For some as yet unknown reason an associated inflammatory process now exists and here we have the so-called phlegmasia alba dolens or milk-leg with massive edema of the entire lower extremity. There is generally considerable evidence of the vasospasm as manifested by diminished arterial pulsation and often a clammy cold extremity. Associated with this are pain and redness along the femoral vein. There may be associated chills; fever is commonly present and there is a leukocytosis and an elevated sedimentation rate.

If femoral vein section is decided upon as a treatment of choice in any of the first four stages, the preferable sites of election are: (1) Superficial femoral vein section which is carried out in Stages 1 and II phlebothrombosis without embolism. This includes early tibial and moderately advancing femoral phlebothrombosis. Corroboration of the diagnosis is made at surgery by finding a non-dilated superficial femoral vein devoid of perivascular inflam-

mation. Phlebotomy will disclose absence of clot. The vein can be freed easily from the artery. The profunda should be soft, non-dilated and free of clot. Assuming there is unilateral involvement, the incision should be made in the femoral triangle and the femoral sheath opened and the aforementioned findings sought for. Superficial femoral vein section may be carried out with a reasonable degree of safety. It will prevent the great majority of emboli but will not control a minimal source of future potential emboli from the saphenous and profunda veins. Simultaneously, section at this level will result in little or no permanent postoperative edema. This vein was ligated in 62 per cent of our cases. (2) Independent superficial and deep femoral section is the second choice.

The indications may be (1) therapeutic or (2) technical. In some cases of Stage III phlebothrombosis without embolism there may be clot in the profunda and none in the superficial femoral vein. Under these circumstances superficial femoral section plus profundal section and thrombectomy are indicated. This will provide a reasonably adequate collateral circulation via the muscular branches and the saphenous vein. In other circumstances when the femoral sheath is opened in the femoral triangle one will find that the distance between the point of entrance of the profunda into the femoral vein and the entrance of the saphenous vein into the femoral is exceedingly short, making it technically difficult or practically impossible to clamp, divide and securely tie the common femoral vein adequately between the point of entrance of the profundus and the saphenous. Under these circumstances one can independently free up the superficial femoral vein and then the profunda and divide them independently. This will give similar protection to that afforded by common femoral section. This was carried out only 4 per cent of the times.

Allen<sup>13</sup> carries out this procedure at all times in preference to common femoral vein section, stating that a more adequate col-

lateral circulation prevails. (3) Common femoral section below the saphenous vein is a third type. Our indications for section here are (1) all stages phlebothrombosis with embolism, (2) cases of Stage III or IV phlebothrombosis without embolism in whom anticoagulants are contraindicated. This refers to the case of phlebothrombosis with a well advanced loosely or partially attached propagating embolus present in upper femoral or iliac veins, with or without concomitant clot in the profunda. Here on opening the vein in the femoral triangle one will commonly find clot present at this point. There will be much perivascular reaction and it will be difficult to separate the artery from the vein. Common femoral vein section was carried out in 37 per cent of the cases. Under these circumstances one should perform a proximal and distal thrombectomy by inserting an aspirating cannula into the vein both proximally and distally. A short nick is made in the vein between guy ligatures just above the point of entrance of the profundus and just below the saphenous. If clot is removed proximal to the point of entrance of the saphenous and even up into the iliac vein, one should also make every effort to aspirate all the clot distal to this point to avoid increased edema following femoral section and to improve the collateral circulation more promptly. If clot is present at the point of operation on the femoral triangle, it would appear to be preferable to carry out ligation at a point definitely above the uppermost level of the thrombus through a normal segment of vein.<sup>14</sup> This would mean either common iliac or caval ligation. In our opinion this is not always practical. It is likewise the belief of others. Donaldson<sup>15</sup> of the Massachusetts General group, too, believes that intervention at the iliac or vena caval level is unnecessarily hazardous and carries a disturbing morbidity and forbidding mortality (as shown in a report of caval ligation by Moses, Allen)<sup>16,17</sup> and the Boston group practically never ligate the common femoral vein but prefer superficial femoral vein section and throm-

bectomy. They ligate the profunda also independently if it is a site of thrombus formation rather than carry out a common femoral section which in their opinion is very disabling. In their clinic (Donaldson) caval ligation is now reserved for patients presenting septic emboli, the source of which is or has extended above the femoral level. However, Veal and De Takats<sup>18</sup> do believe in section through normal vein above the level of the thrombus and do carry out iliac and caval section. Bancroft,<sup>19</sup> on the other hand, endorses common femoral section and thrombectomy if clot has extended up to the level of the iliac vein.

Caval ligation has not stood the test of time and we do not believe that routine common iliac vein ligations are a procedure of choice inasmuch as it generally necessitates the administration of a spinal anesthetic for the conduct of the operation with resultant flexion of the thigh and legs, on the trunk and increased probability of detaching pulmonary emboli which may be fatal. Very often one has a critically ill patient in whom spinal anesthesia is out of the question. Under these circumstances we prefer to carry out common femoral vein section just below the entrance of the saphenous vein. Further, Homans,<sup>20</sup> who is generally considered to be the Dean of the ligation school, has clearly stated what he considers at the present time to be the indications for and preferred levels of ligation. It is to be emphasized that he regards vena caval ligation only as a last resort to be employed when repeated embolism has continued to occur despite peripheral venous ligation and/or adequate anticoagulant administration. His statement that certain forms of peripheral venous thrombosis, in which pulmonary embolism has not occurred, may be adequately handled by medical management reflects a change in viewpoint by the surgical school.

We believe that common femoral vein section is indicated under any circumstances as long as pulmonary embolism has occurred. This is especially true in

Stage I or II phlebothrombosis, for here on opening the femoral vein one will not demonstrate thrombus. However, because pulmonary embolus has occurred and because one cannot be certain with an adequate degree of accuracy that thrombus does not exist in the profunda, we believe the only safe thing to do under these circumstances is to ligate the common femoral vein below the saphenous vein. This will result in greater morbidity as manifested by edema in the lower extremity. Statistically, however, this is a more desirable operation even in early phlebothrombosis in which clot is present only in the calf veins, etc., because one is weighing the possibility of death from another embolus against the factor of morbidity. Obviously the former is the more important objective to overcome.

Common femoral section above the saphenous vein represents the fourth type. This is indicated rarely in cases of the very well advanced phlebothrombosis in which a fully developed femoro-iliac thrombophlebitis does not occur and in which one operates because of recently detached pulmonary embolus. Here findings should demonstrate the presence of clot in the saphenous vein. Under these circumstances the common femoral vein section is carried out above the saphenous vein to prevent the possible detachment of thrombus from the saphenous circulation. Because of marked postoperative edema this is an especial indication, if feasible, for common iliac section.

Based on the above, vein resection may be carried out under the following circumstances: (1) If early diagnosis is made; (2) if anticoagulant therapy is ineffective or contraindicated and (3) if embolism occurs.

On our service the following plan of management of phlebothrombosis of the lower extremities is carried out. In Stages I, II, III and IV phlebothrombosis without accompanying pulmonary embolism we routinely start anticoagulant therapy at this time. This is based on statistical evi-

dence as exemplified by the Mayo Clinic where Barker<sup>21</sup> et al. showed that in a group of a thousand surgical patients who were given Dicumarol in their immediate postoperative period for the purpose of preventing venous thrombosis and pulmonary embolism, only one death occurred from pulmonary embolism. This occurred after the prothrombin had returned to normal because Dicumarol had been given for an insufficient time. In their group they state that the extremely low incidence of fatal pulmonary embolism in a thousand postoperative cases would not be remarkable if the cases had been unselected but most of them for a matter of fact had been selected. The thrombotic tendency had already been demonstrated in 379 patients in that they already had thrombosis or embolism. In 438 abdominal hysterectomy had been performed, an operation in which the statistical risk of thrombosis and embolism is known to be greater than in most operations. Hence, based on the above study over 40 per cent of the patients had already developed phlebothrombosis and were given therapeutic Dicumarol. The above is also borne out in other studies. Lowe<sup>22</sup> has demonstrated the effectiveness of heparin in Pitkins menstruum in thromboembolism both prophylactically and therapeutically. Bauer,<sup>23</sup> of the Swedish group, has employed regular heparin with success. He strongly endorses it in the treatment of deep venous thrombosis.

Based on these statistics we believe that it is reasonably safe to institute anticoagulant management once the diagnosis of phlebothrombosis without embolism has occurred. We believe also that anticoagulants will protect the patient against an embolus in the greater majority of instances although this is not exclusively so. This is borne out by the experience of Ochsner<sup>24</sup> who observed emboli in patients who were under adequate anticoagulant effect. Emboli occurring under similar circumstances have also been reported by Cosgriff.<sup>25</sup> In his series ninety-six patients presenting the clinical picture of acute deep



venous thrombosis of the lower extremities were treated with anticoagulants, such as heparin and Dicumarol. With the exception of six patients treated with heparin alone and two with Dicumarol alone, all patients received Dicumarol with concurrent heparinization during the first one to three days of the treatment period. Subsequent to starting therapy, three patients experienced small non-fatal pulmonary emboli. All of these emboli occurred prior to the sixth day of *adequate* anticoagulant effect, one following almost immediately after manipulation of the patient during the administration of a paravertebral lumbar sympathetic block. No fatal emboli occurred in any patient of this group.

Embolization was encountered in three of the ten cases of acute thrombophlebitis of the deep veins. Examples such as these three cases have served to strengthen our belief that even the acute inflammatory deep venous thromboses (thrombophlebitis) should receive anticoagulant treatment as well as symptomatic measures such as sympathetic block because of the possibility of dangerous bland thrombus material either proximal to the inflammatory thrombosis or in the contralateral deep venous system. An embolus occurring during treatment with anticoagulants is further illustrated in the following case:

The patient had a subtotal gastric resection carried out for carcinoma of the stomach. About the tenth postoperative day he began to show signs of phlebothrombosis in one leg. He was placed on anticoagulant management with adequate doses of Dicumarol and heparin. About the third or fourth day after the institution of anticoagulant management he developed evidence of a pulmonary embolus. This was not confirmed by radiograph, however. The findings were those of severe pain in the chest, precordial pressure, dyspnea, cyanosis, shock and hemoptysis, the classic findings of pulmonary embolism with associate accompanys of elevation of temperature and pulse. It is possible that he may have had a retrocardiac pulmonary embolus which was not visualized on x-ray. Examination at the time disclosed findings co-existent with diagnosis of

Stages II or III phlebothrombosis. He had a positive Homans' sign, dilated superficial veins, slight cyanosis of the leg and very early edema. It was believed that we were dealing with a Stage III phlebothrombosis. Anticoagulants were discontinued. He was given vitamin K and whole blood and within eighteen hours common femoral section was carried out. Thrombus was not demonstrated in the common femoral vein; however, because the patient had had a pulmonary embolus, common femoral vein section was carried out. He made an uneventful recovery and had just a minimal amount of residual edema.

In Stages III and IV phlebothrombosis, with anticoagulants contraindicated, without embolism, femoral vein section with proximal and distal thrombectomy is carried out. Here the superficial or common femoral vein is ligated depending upon the site and amount of clot. Distal thrombectomy helps reduce postoperative edema.

On the other hand, irrespective of the stage of thrombosis but exclusive of acute femoro-iliac thrombophlebitis, once a pulmonary embolus has occurred we believe the only safe thing to do is to carry out common femoral vein section, preferably below the saphenous vein. Under these circumstances it is considered unwise to institute only superficial femoral vein section even if a thrombus is not demonstrated at the level of phlebotomy. Our reasoning here is based on the statistical evidence of 3 to 4 per cent<sup>26</sup> chance of further emboli with a 1 per cent mortality. Our postoperative mortality under these circumstances was 2.4 per cent. It is then clear that in superficial femoral vein section there is no protection against pulmonary emboli arising from the profunda, the saphenous vein or possibly the other leg. Fine and Sears<sup>27</sup> share the same belief. They state: "Regarding the safety of ligating the superficial femoral vein one is impressed by the frequent efforts reported to preserve the profunda femoris vein, but the attempt is not safe. The site of thrombosis may be in this very vein and the patient may die of embolism."

About three of four years ago superficial femoral vein section was our practice in Stages I and II phlebothrombosis with emboli. However, following the occurrence of a death in one of our patients under these circumstances the procedure was abandoned and since then common femoral section as described earlier has been our policy. While common femoral vein section as above is the procedure of choice in phlebothrombosis Stages I, II, III, and IV with pulmonary embolism, it is not a completely adequate procedure in the light of our present experience. More adequate management is effected by complementing the above surgery with anticoagulant treatment. The basis for this lies in our own experience and that of others. We observed post-ligation embolism early in about 8 to 10 per cent of cases.

Donaldson<sup>28</sup> reporting on a series of 3,185 femoral vein interruptions in 1,692 patients over a ten-year period from the Massachusetts General Hospital cited a 4 per cent incidence of post-section pulmonary emboli. It is of interest that practically all of this group who suffered subsequent pulmonary emboli had been subjected to femoral vein interruption because of previous pulmonary infarction. Of the 3,185 sections about two-thirds were for active disease and one-third were carried out as a prophylactic measure. Five patients in the group of 1,033 therapeutic interruptions succumbed to proven subsequent emboli. In none of these earlier cases was anticoagulant treatment used.

Other additional valid reasons for advocating the use of anticoagulant treatment following ligation may be advanced from the following: Murray<sup>29</sup> has emphasized the usefulness of heparin administration in the patients with severe pulmonary embolism. He believes that propagation of thrombus material from the site of embolus lodgment may be avoided if anticoagulant administration is immediately started and the incidence of fatality due to the original acute episode thus reduced. De Takats<sup>30</sup> analyzed a group of patients

who died from pulmonary embolus and concluded that 60 per cent live for a period of one hour to several days. He concluded that if the cause of some of the delayed deaths from pulmonary embolism is the propagation of thrombus material in the pulmonary artery, a fertile field of endeavor is opened to the employment of anticoagulants. Carlotti et al.<sup>31</sup> in a recent report from the Massachusetts General Hospital stated that thrombus formation proximal to the site of venous ligation was found in more than 50 per cent of a small group of medical pulmonary emboli patients who were treated by ligation and later examined at autopsy. These two preceding reports suggest that there is a rational basis for the employment of anticoagulants even as an adjunct to ligation. Carlotti<sup>32</sup> also reported a 21 per cent incidence of postoperative pulmonary infarction in a series of sixty medical patients who had common femoral sections. Veal and Hussey<sup>33</sup> observed three deaths from massive pulmonary embolism in cases of acute ileofemoral thrombophlebitis in which a new clot was engrafted on the old. They expressed the opinion that there is danger of embolism in all cases of venous thrombosis for as long as four months afterward. Their preference is to ligate the common femoral vein distal to the saphenous vein. In forty-five ligations there were 20 per cent instances of embolism after ligation in the cases in which ligation was performed before the embolism was evident. The above is additional evidence that a need exists for post-ligation anticoagulants.

With the above supporting evidence we now institute anticoagulant (unless contraindicated) treatment about twelve hours following common femoral vein section for Stages I, II, III and IV phlebothrombosis with embolism. We use both heparin and Dicumarol in our clinic, carrying the patient on heparin until there is an adequate Dicumarol effect noted as evidenced by a sufficient depression of the prothrombin level of the blood.

The detailed management of Stage V

phlebothrombosis which is acute femoroiliac thrombophlebitis does not fall into the realm of this paper. It is generally agreed that treatment should be directed toward relief of vasospasm by (1) repeated paravertebral lumbar sympathetic blocks (2) heat and (3) drugs that produce block of autonomic impulses such as etamon. Further attention should be given to the systemic effects of the disease by general support and chemotherapy, etc. In addition, because of the occasional embolic phenomena in thrombophlebitis we now recommend the use of anticoagulants. This is given in conjunction with the above measures.

We have had three cases of femoroiliac thrombophlebitis, one acute and two chronic recurrent cases that have had embolic phenomena. Fortunately, none of the three were fatal. This is again mentioned to dispel the laissez faire attitude that we and probably others have previously had about emboli under these circumstances.

The frequency and relationship of unilateral and bilateral phlebothrombosis is variously related. The literature indicates that bilateral phlebothrombosis occurs with much greater frequency than unilateral. These observations are stressed in the works of Homans<sup>34</sup> and Allen and Linton,<sup>35-37</sup> all of the Boston group. They believe that the site of thrombosis in the lower extremities is difficult to determine and they advocate bilateral femoral vein section. In our group of cases bilateral femoral phlebothrombosis was diagnosed in 9 per cent of the cases.

The indications for therapeutic unilateral or bilateral femoral vein sections may be based on findings of physical examination. If one can demonstrate to his own satisfaction the presence of phlebothrombosis in a particular extremity, he should treat it as such. On the other hand, unless there are actual positive findings present in the opposite extremity, it is our belief that one need have little fear concerning the presence of an embolus arising

in the opposite extremity. This observation is made with the provision that the extremity be watched often enough and closely enough. Under these circumstances if phlebothrombosis should develop in the opposite extremity, it would be discovered very early. If it did develop subsequently, the same principles of management should be effected. This, too, is in accord with the ideas of Bancroft, who in a recent discussion on thromboembolism stated: "I disagree with Allen and his co-workers that it is necessary to ligate both sides every time; in my experience if the thrombus starts in the veins of the calf and is seen early and that vein is ligated then I have *never* seen it occur on the other side."

The matter of bilateral superficial femoral vein section as a prophylactic measure to be carried out more or less anticipating possible emboli in certain patients, especially the older age groups who are to have radical surgery for malignancy, etc., is an entirely different matter.

In determining the sites of femoral vein section one critical consideration should be the postoperative morbidity, especially the degree of postoperative edema that may ensue. Obviously it is desirable to ligate the femoral vein as low as possible. The lower the ligation the less the edema. If one can safely carry out superficial femoral vein section, this should be the procedure of choice in respect to the amount of resultant edema. In our study superficial femoral section practically never resulted in permanent edema. If edema did develop immediately after operation, it was minimal and more or less disappeared completely in a very short time. On the other hand, section of the common femoral vein below the saphenous system will result in varying degrees of edema. Several years back practically all of the patients developed an appreciable degree of edema with common femoral section. Of those that were followed, notably two, phlebitic ulcers developed which were refractory to treatment. At the present time we are not quite as concerned about ligating a common

femoral vein as we were formerly. This is because of more detailed attention to leg care with less resultant edema. Special emphasis should be placed on adequate elevation of the leg immediately after operation and the use of ace bandaging of the extremity for several months. On the other hand, in common femoral section above the saphenous vein there is practically always a marked degree of edema. This operation is rarely indicated. Edema ensues essentially because the complete circulation of the lower extremity is abruptly occluded at one time and the collateral circulation develops very slowly.

At this time mention should be made of the place of venography, (1) in the diagnosis of phlebothrombosis and (2) as an aid to femoral section. Several years ago venography played an important role in establishing a diagnosis of phlebothrombosis of the lower extremities. As time went on it became apparent, however, that the venogram was not always diagnostic and was a rather difficult type of radiogram to interpret. This has been our experience; and whereas formerly we did venograms on practically all cases of whom we suspected phlebothrombosis, we now have largely abandoned this procedure. At present it is only an exceptional case in which venography is done. We believe that the diagnosis of phlebothrombosis can be made principally on physical findings. In addition, venography may also be misleading in that it is difficult to assess the normal from the abnormal because of the numerous anomalies that are present in the deep venous circulation of the lower extremities. Before being able to read a venogram accurately, it is necessary to do a good number of normal lower extremities to determine what the normal is. Only then can one appreciate the abnormal. We originally carried this out in a representative number of normal cases and even after that it was found by both the radiologist and myself that accurate interpretation of venograms was often difficult, especially when only the anterior and posterior tibial and

peroneal veins were involved. When the thrombus has progressed to the popliteal vein or into the femoral vein, the venograms are usually quite clear. On the other hand, physical findings under these circumstances were so obvious that a venogram was really not necessary anyway. This is the consensus held by most men interested in the problem, and most of them also have abandoned venography as an adjunct to the diagnosis of phlebothrombosis. As far back as 1944 and 1945, Barker<sup>38</sup> and his group noted that venography gave no positive results in about a third of his cases. He was in favor of abandoning it at that time and as far as we know he has done so since then. Similarly Kleinsasser,<sup>39</sup> in a study of serial phlebograms made in 110 cases of intravascular clotting at the DeWitt General Hospital vascular center, concluded that they were of no value so far as early detection of phlebothrombosis was concerned and also of no value in identifying its location even when the occurrence of pulmonary embolism had directed attention to its existence. His conclusion was that a recollection of the possible occurrence of the condition was of far more value than any laboratory method.

Any presentation of phlebothrombosis would be incomplete without reference to the role of prophylaxis. Here may be mentioned suitable preparation of the patient for operation. This should include reduction of weight if the patient is obese, correction of anemia, elimination by injection or surgical resection of major varices in the lower extremities, medical supervision of cardiac abnormalities, adequate diet and adequate physical activity preoperatively. Gentle handling of the tissues in surgery and prevention of stasis in the leg veins during convalescence, elevation of the foot of the bed and leg exercises are widely considered useful. On the other hand, there is still reasonable doubt as to the true value of early ambulation as an effective prophylactic measure against thromboembolism. Allen<sup>40</sup> remarks about the reduction in the

over-all incidence of thrombosis and fatal embolism in postoperative cases from 1 in 333 to about 1 in 800 at the Massachusetts General Hospital. On the other hand, Powers<sup>41</sup> in a recent clinical study of the effects of early ambulation in 1,590 major surgical cases concluded that the incidence of postoperative thrombosis was not favorably influenced nor was the hazard of pulmonary embolism eradicated. He believed that an early return to customary activity following early ambulation was the only beneficial effect. Still more significant are the findings of Blodgett and Beattie<sup>42</sup> who analyzed 681 cases at Peter Bent Brigham Hospital and observed that following early postoperative rising the incidence of deep leg vein thrombophlebitis was actually somewhat greater in the early rising group.

Therefore, inasmuch as avoidance of unnecessary prolonged bed rest by early ambulation has not eliminated thrombotic phenomena, it is only logical to single out individuals on whom clinical experience has shown have an increased predisposition to thromboembolism. Active prophylactic measures could be carried out in this group. The group should include the following circumstances: (1) A history of previous thromboembolism predisposes to recurrence. (2) Disturbances of venous circulation, such as extensive varicosities, favor the development of thromboses. (3) Individuals with malignancy suffer more frequent and recurrent thromboses. (4) Extensive abdominal and pelvic surgical procedures, particularly those performed for malignancy (such as abdominoperineal resection for cancer of the rectosigmoid), are complicated by far more than the average number of thrombotic phenomena. (5) Fractures of the femur and amputations of lower extremities are followed by a remarkably high incidence of thromboembolism (as high as 10 per cent of fatal embolism in older patients). (6) More than 60 per cent of all postoperative venous thromboses and emboli occur in the age group over fifty years and more than 80 per cent in the age group over forty

years. (7) Thromboembolism occurs at least twice as frequently in obese individuals as in those of normal weight. (8) Cardiac insufficiency, with its attendant disturbances of venous return, greatly increases the risk of thrombotic episodes.

#### COMMENT AND CONCLUSIONS

Phlebothrombosis with its thromboembolic complications continues to be a problem in management. It is believed that the pathogenesis and sites of origin are now generally known. For clarity these points have been re-emphasized and reviewed. Thrombosis begins in the deep veins of the leg and foot and may propagate and go on to embolism before it gives rise to marked clinical manifestations. It is necessary, if it is to be detected before complicating embolism has occurred, that the possibility be borne constantly in mind. It should always be considered as a possible development after operation. It often occurs in medical patients. Detection is a matter of constant watchfulness. It involves repeated palpation of the extremities, the taking and recording of serial measurements and repeated observations of the pulse rate, temperature and respiration. Electrocardiography may be very useful but venography has declining importance as a diagnostic aid. The value of electrocardiography has been graphically demonstrated in our clinic; in at least five of our cases phlebothrombosis was diagnosed only after the cardiologist discovered evidence of acute cor pulmonale on the electrocardiograms compatible with pulmonary embolus; then after more careful examination of the extremities thromboembolic disease was ascertained.

Despite the voluminous literature written on the subject a misunderstanding as to the indications and levels for femoral vein section still exists. This is based on disagreement among the leaders in this type of management. We believe many factors should be taken into account in determining levels for section. We especially emphasize the role and place of physi-

cal findings. Other important factors to consider are postoperative morbidity, sequelae, the reliability and effectiveness of anticoagulant agents, prophylactic measures and finally the incidence of pulmonary embolism under various conditions and especially after femoral section at different levels. A big problem is the unknown degree of danger in each case of phlebothrombosis. The dangerous character of phlebothrombosis is evident from the fact that it is frequently unsuspected until potentially fatal accident of pulmonary embolism occurs. Every detection is difficult unless the condition is constantly being suspected. The existence of this problem is emphasized when it is noted that statistics show that  $2\frac{1}{2}$  to 5 per cent of deaths are attributable to pulmonary embolism. If the pulmonic process is not properly diagnosed, the patient may continue to have showers of pulmonary emboli which are regarded as manifestations of pneumonia or cardiac disease and which may eventually terminate fatally although this is not an inevitable end result. Pulmonary infarction was fatal twice in our small series after ligation. Pulmonary infarction was not fatal in any case of an army series of 502 instances (Kleinsasser).<sup>43</sup>

White<sup>44</sup> has commented on the increasing number of cases in his own experience which he once would have diagnosed as congestive heart failure but which he now recognizes as pulmonary embolism originating in phlebothrombosis; the cardiac disease, of course, is a possible complication. In seventy-five cases which White studied and in which cardiac disease was a possibility, it was actually present in forty-seven; the remaining twenty-eight were true instances of pulmonary embolism originating in phlebothrombosis. In his experience at the Massachusetts General Hospital 70 per cent of the patients with pulmonary embolism of non-surgical origin had symptomless clotting insidious in onset and situated in the deep veins. The differential diagnosis of pulmonary embolism is frequently possible on the basis of

periodic attacks of faintness, dyspnea, prostration, unexplained fever, leukocytosis and, rarely, jaundice. X-ray diagnosis is often disappointing except in the case of wedge-shaped infarctions. Suspicion of the possibility of embolism and constant close observation is the key to successful diagnosis. Once pulmonary infarction has directed attention to the existence of intravascular clotting it is urgent that measures be taken to prevent its recurrence since this is a real possibility. Ziak<sup>45</sup> pointed out that 70 per cent of patients who die from pulmonary embolism have had previous attacks of pulmonary infarction, and Graves in a study of 194 cases found that while 140 patients had only a single attack, some had as many as eight.

Not more than 20 to 25 per cent of all pulmonary emboli are immediately fatal. According to Ziak at least 60 per cent of the patients live from one hour to several days. In only forty-five of 154 fatal cases in the Graves series did death occur within an hour or less. De Takats and Fowler<sup>46</sup> have also emphasized the fact that in most instances of embolism there is time for treatment, first, during the actual episode, then for the prevention of other attacks which are increasingly dangerous as their number increases. Approximately one-fifth to one-fourth of these emboli are fatal at the outset.

We treat all phlebothrombosis without pulmonary embolism with anticoagulants (heparin and Dicumarol) unless there is a contraindication to their use. In phlebothrombosis with embolism we carry out common femoral vein section below the saphenous vein with or without thrombectomy as indicated. This is usually unilateral and much less frequently bilateral. We advocate postoperative anticoagulants as an additional safety factor here. Superficial femoral vein section is usually adequate in our so-called Stages I and II phlebothrombosis without embolism. In Stages III and IV without embolism both superficial and femoral vein ligation may be necessary. More often common femoral

section without thrombectomy is indicated here. We do not hesitate to ligate the common femoral vein. We prefer it to common iliac and caval section notwithstanding the supposed more adequate collateral circulation. Common iliac and caval section do have their shortcomings and dangers. Femoral section is rarely if ever indicated in acute femoral iliac thrombophlebitis. Here measures should be directed toward relief of vasospasm and toward the systemic aspect of this disease. In addition we now recommend anticoagulant measures to prevent the occasional pulmonary embolus that can occur and we highly recommend detailed attention to prophylactic measures.

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THE Thirteenth Congress of the International Society of Surgery will meet in New Orleans October 12th to 15th, inclusive. A distinguished gathering is expected from the United States and many foreign countries. An excellent scientific program has been arranged. There are four scientific sessions but the last two days of the meeting will be given over to an American program, all the speakers being from the United States. Honorary chairman is Dr. Rudolph Matas in whose honor New Orleans was chosen for this year's meeting. Dr. Matas is the only living American past president of the Society. The other American president was the late Dr. W. W. Keen of Philadelphia who was elected in 1914 when the Congress met in New York.



# CLINICAL EVALUATION OF A NEW BACTERICIDAL AGENT\*

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THE purpose of this paper is to give the results of a clinical study of infected wounds using a new bactericidal agent, Heliogen, in comparison with accepted chemotherapeutic agents.

Heliogen is a white powder composed of the mixture of chloramine-T, potassium iodide, dextrose and sodium biphosphate in definite proportions. The pH of the preparation is close to neutrality changing from 7.32 to 7.03 after thirty minutes at room temperature. On contact with water iodine is released.

As the name Heliogen implies, a small amount of ultra violet light is emitted as a result of the chemical reaction which the preparation undergoes in solution. The wave length has been determined by Dr. Ralph H. Müller, Washington Square College, to be in the range of 2,850 to 3,000 Ångströms. This is an interesting observation from the academic point of view and, as the reader doubtless knows, is not a unique phenomenon. An example familiar to every one is the luminescence of biochemical origin which has been studied and described in a monograph by Harvey.<sup>1</sup>

Bactericidal tests *in vitro* have shown that Heliogen is effective in killing a wide variety of micro-organisms. Toxicity studies by the Department of Therapeutics of The New York University College of Medicine indicated that Heliogen preparations were, "of sufficiently low toxicity to warrant controlled clinical study at the hands of properly qualified investigators." In these clinical studies Heliogen was used in two forms: (1) a powder for preparing an

aqueous solution; (2) a powder for dry application which had a much lower content of iodine in order to avoid excessive concentration in tissue fluids.

Conditions were kept as constant as possible. Dressings were applied daily by the same team at the same hour of the day, wound cultures were collected in the same way and the general management of the patient's systemic condition and regulation of his activity remained consistent throughout. In each of the controlled series patients were assigned in rotation to each type of therapy so that no extrinsic factors entered into the selection. The fact that this study was completed before penicillin was generally available accounts for the lack of mention of its use in many cases in which patients might have benefited from it and even survived the overwhelming infection which produced some of the mortalities.

## SERIES I: PRELIMINARY GROUP

All but two of the twenty-one patients had chronically infected wounds which had not responded appreciably to various treatments including antiseptics and the sulfonamides.

In this series no controls were used but it was thought that the results were significant because of the various therapies tried unsuccessfully before admission of the patients to this series; an example is Case 10. The patient was a nine year old boy with a wound infected for two and a half years following a thoracoplasty. Previous treatments consisted of sulfathiazole, gen-

\* From the Departments of Surgery and Bacteriology, Long Island College of Medicine, Brooklyn, N. Y. The study was initiated at the request of the Health and Medical Committee, Council of National Defense. The work has been supported in part by a grant from the Heliogen Corporation. The preparation is available only for experimental work.

tian violet packing, zinc peroxide, azochloramid and Dakin's solution. After Heliogen irrigations were begun, the discharge rapidly decreased. Clean granulations started at the lower border of the wound. A subpectoral abscess of the right chest wall was incised and drained. Following this the amount of discharge from the sinus diminished greatly and epithelization at both ends of the wound progressed rapidly. The patient was discharged after seventy-one days with the wound practically healed.

All wounds were irrigated with Heliogen solution; in eight cases this was followed by application of the powder in dry form.

A review of these cases leads us to the following conclusions: (1) In no case was there any undesirable effect from Heliogen treatment either locally or systemically. (2) The growth of granulations was not inhibited and in some cases epithelization seemed to be hastened. (3) In no case was there an exuberance of granulations. (4) The appearance of the scar tissue was good. (5) There was usually in grossly infected wounds a slight discomfort lasting about fifteen to twenty minutes after irrigation but this disappeared as healing progressed. (6) Chronically infected wounds which had been resistant to various other therapies seemed to progress favorably under Heliogen treatments.

#### SERIES II: CONTROLLED GROUP

*Solutions.\** Patients with infected wounds which appeared to have free drainage were selected and assigned in rotation to one of four types of therapy. The substances used in treatment were:

1. Saline and peroxide, ten cases  
Physiologic saline 75 per cent by volume  
Hydrogen peroxide 25 per cent
2. Heliogen powder for solution, ten cases  
2.5 to 10 Gm. in 1 L. of water

\* Both controlled series of cases were carried out after consultation with the Committee on Chemotherapeutics and other Agents, National Research Council.

3. Compound solution of iodine, U.S.P.  
X1, ten cases  
Iodine concentration equal to that of Heliogen

4. Azochloramid in saline, ten cases  
Dilution 1:3300

*Saline and Peroxide.* Two of the patients in this group expired from extraneous causes. In Case 26 the wound showed 10 per cent healing after twelve days of irrigation with saline and peroxide. The patient expired with jaundice on the thirteenth day. In Case 64, after irrigations of a decubitus ulcer with saline and peroxide for three days, the wound had shown no progress; the patient expired from advanced carcinoma of the cervix. One patient (Case 42) would not cooperate in keeping fecal matter from the wound, which failed to improve with three days of saline and peroxide irrigations and thirty-seven days of Heliogen treatments.

In the remaining seven cases wound progress with saline and peroxide was satisfactory but in general healing was slow, as in Cases 38, 26, 46 and 30. In three of these cases the patients required additional therapy with saline irrigations or daily hot baths before healing was complete.

There was no undesirable reaction to the saline and peroxide treatments either locally or systemically.

*Compound Solution of Iodine, U.S.P. XI.* Of the ten in this group three patients expired. In Case 60 the wound was an infected amputation stump of a diabetic. After fourteen days of aqueous iodine irrigations the infection was spreading and six days of Heliogen therapy were without effect. Additional drainage of the wound was necessary but the patient's systemic condition did not permit operation and death ensued from cardiac failure.

In Case 24 a deeply infected amputation stump of a diabetic failed to respond to three days of aqueous iodine irrigations and the patient expired of generalized gas gangrene. The patient in Case 52 was also a diabetic. After eight days of aqueous iodine irrigations the infection was not

controlled and the patient expired with diffuse infection and spreading gangrene. In case 44, after eight days of irrigation with aqueous iodine, the wound was worse. The patient was discharged with a gelatine paste boot and subsequently improved.

Two patients (Cases 40 and 56) showed but slight improvement under aqueous iodine therapy. They were transferred to Heliogen treatments and progress was made. These cases are discussed under Changes of Therapy. In one patient (Case 32) the wound showed 80 per cent healing in thirty-eight days of aqueous iodine irrigations and then remained static. In twelve days of subsequent Heliogen therapy the wound healed completely.

In the remaining three patients (Cases 28, 36 and 48) the wounds healed completely under iodine therapy. In Case 48 an infected laceration of the knee 7 cm. in length required skin grafting. The first attempt did not take but the second succeeded. In Cases 28 and 36 the wounds healed satisfactorily.

In general wounds treated with aqueous iodine became clean but progress was of very limited proportions. The majority of the patients complained of a moderate burning sensation of thirty to sixty minutes' duration following each irrigation. No systemic toxicity was observed but there was one instance of skin irritation (Case 32).

*Azochloramid.\** Two of the ten patients in this group expired from systemic conditions. In Case 23 the patient was admitted with cerebral concussion and multiple fractures. Seventeen days later a decubitus ulcer developed and eleven days afterward an abscess of the leg. Under daily irrigations with azochloramid both wounds failed to improve and the patient expired from bronchopneumonia thirty-eight days after treatment began.

When admitted, the patient in Case 35 was very weak. There were two wounds; one was an infected ulcer of five years' duration which was treated with azo-

chloramid; the other (later) a gangrenous decubitus ulcer on which Heliogen was used. After twenty-three days of azochloramid the ulcer was cleaner and had decreased 25 per cent in size. After six days of Heliogen irrigations the spread of gangrene was halted in the ulcer. However, the patient's condition deteriorated and she expired twenty-four days after treatment began.

In two cases azochloramid was discontinued because of a severe, burning sensation from the treatments. In Case 27 the foul-smelling discharge disappeared after ten days of azochloramid irrigations but because of severe pain, the therapy was changed to normal saline irrigations. The wound healed completely in thirty-eight days. After eight days of azochloramid irrigations the patient in Case 31 refused further treatment of infected burns because of the severe pain. At that time there was no change in the culture and very little healing.

Of the remaining six cases, two patients showed no improvement under azochloramid (Cases 38 and 55) and one became worse (Case 51) but all three improved under Heliogen treatments.

One patient (Case 43) showed no improvement with either azochloramid or Heliogen treatments but an exploratory operation revealed osteomyelitis deep in the pelvis. Another patient (Case 47) showed a slight regression of the wound but no change in its appearance after twenty days of azochloramid irrigations. The wound healed completely in forty-two days with repeated hot Sitz baths. In Case 59 a satisfactory course was followed under azochloramid treatments. There were two wounds, one of which healed completely; the larger one was practically healed after fifty days of treatment.

The results obtained with azochloramid were disappointing. The wounds, except in Case 31, appeared clean after irrigations but the expected healing did not occur.

*Heliogen Solution.* In this group of ten cases one patient expired. In Case 45 the

\* Supplied by Wallace and Tiernan Company.

Clinical Evaluation of a New Bactericidal Agent. By ALLEN J. RYAN, M.D., FLORENCE M. STONE  
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*The American Journal of Surgery*

*October, 1949*

## Clinical Evaluation of a New Bactericidal Agent

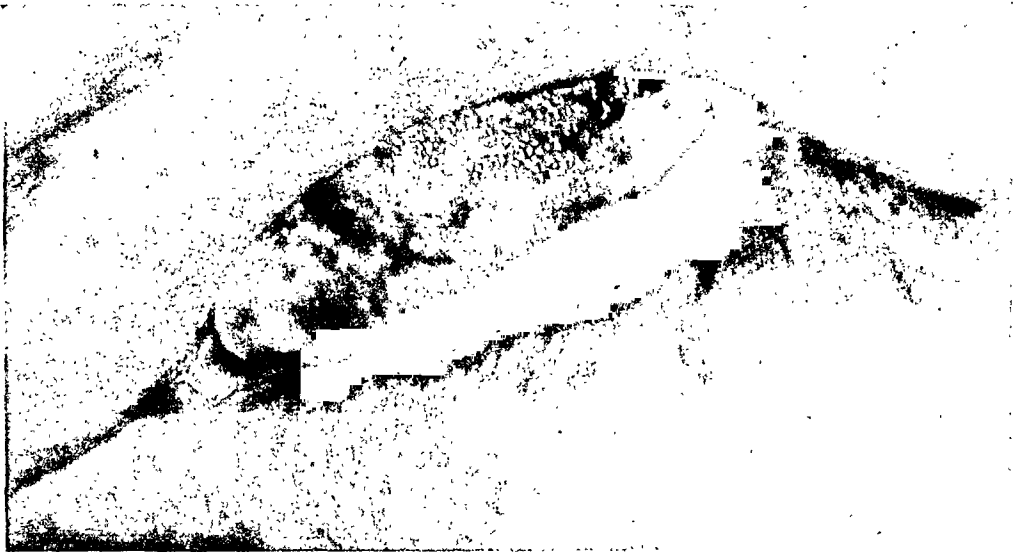


FIG. 1 CASE 25. Appearance of lesion nine days after Heliogen treatment was started. The patient is lying on his side with his head at the left and his right arm at the top of the picture. The wound extends subcutaneously in all directions, connecting at the inferior border with the sinus seen at the extreme right of the picture. Anteriorly and posteriorly there are deep cavities formed by the arching of the remaining ribs and the scapula. The papulo-pustular rash appears to have been associated with an aerobic Actinomyces; actual size.



FIG. 2. CASE 25. Appearance of lesion on the 190th day after Heliogen irrigations were started, the thirteenth day after they were discontinued. The papulo-pustular rash has cleared up. The chest has expanded somewhat allowing the scapula to be pulled up higher, but in addition there has been extensive growth of new skin between the old sinus, which is now healed, and the main wound. No healing has been possible where the trapezius muscle and anterior ribs are holding up the upper layer of skin from the granulating base of the wound which covers the pleura.

## Clinical Evaluation of a New Bactericidal Agent



3

4

FIG. 3. CASE 41. Appearance of wound ten days after treatment with Heliogen solution was started eighteen days after operation. There has already been considerable healing of the lower end of the incision where two granulating areas formerly connected. The greenish necrotic tissue seen in the wounds is fascia and tendon which had to be removed gradually because of the bleeding encountered. A stab wound which was made for independent drainage of a small pocket communicates with the lower wound and can be seen below it. There is also evidence of healing around the edges of the upper wound which was not present when Heliogen was started.

FIG. 4. CASE 41. Appearance of wound at the second operation, the sixtieth day after Heliogen therapy was started and the sixtieth day after the first operation. This wound connects on the surface the deep portion of the original wound with the stab wound seen in Fig. 5. The original wound is otherwise almost healed. The new wound presents the characteristic appearance of a fresh wound in tissue with poor circulation, pale and apparently lifeless, with a thin discharge.

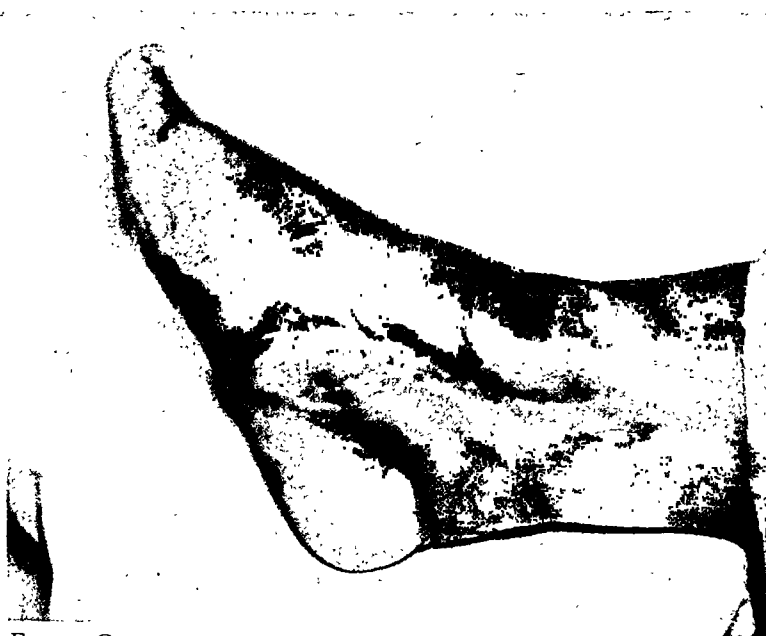


FIG. 5. CASE 41. Appearance of the foot 114 days after the start of Heliogen treatment, 122 days after the first operation and 87 days after the second operation. Complete healing has resulted with a comparatively small scar; one-third actual size.



diabetic patient had a temperature of 105°F. The diabetes was brought under control and the wounds gradually became clean. Although sulfathiazole and sulfadiazine were given orally, blood stream infection persisted and death ensued with the wounds 20 per cent healed.

Two wounds required additional surgery to bring about complete healing. In Case 37 the wound was a chronic empyema cavity. The patient ran a low grade temperature and required blood transfusions. After twenty-five days of Heliogen irrigations there was no change in the size of the wound but there was some diminution in the discharge. The wound needed additional drainage; the patient was referred for necessary surgery and lost to follow-up. In Case 25 (Figs. 1 and 2) the patient had been hospitalized for fifteen months while a chronic draining wound following a thoracoplasty for empyema was unsuccessfully treated with sulfathiazole, Dakin's solution and azochloramid. Under Heliogen therapy the lower portion of the wound filled in, obliterating a dead space and closing a sinus. Epithelization of the exposed granulating base then began. Healing was not complete because of the roofing effect of the ribs. When referred for surgery, the patient had been ambulatory for four months.

Wounds in the remaining seven cases healed completely or showed marked progress under Heliogen irrigations. Two cases are particularly noteworthy because of the difficult problems involved.

The wound in Case 33 was due to a left nephrectomy for tuberculosis of the kidney. The patient's general condition improved, but after three months' treatment with gauze packing, sulfanilamide, sulfathiazole and irrigations with mercurochrome, the wound had not improved and was still discharging. After ten days of Heliogen therapy the discharge was diminished and the wound began to heal. Improvement continued under this treatment until an area only  $\frac{1}{2}$  cm. in diameter remained; a complete excision of the scar tissue was

then made. There was perfect healing by primary intention. Case 41 (Figs. 3, 4 and 5) is of interest because of the relatively small scar tissue from two grossly infected connecting wounds measuring  $14\frac{1}{2}$  by  $4\frac{1}{2}$  cm. and  $11\frac{1}{2}$  by  $2\frac{1}{2}$  cm.

It should be noted that in this group all the wounds had mixed infections and there were some adverse systemic conditions (Cases 29, 41, 45 and 57). Nevertheless, eight wounds showed complete healing or marked progress, one showed 20 per cent healing and in the remaining case a diminution of discharge indicated a slight improvement.

Although several wounds were irrigated daily for long periods because of the nature and extent of the lesions (Cases 25, 33 and 41), there was no evidence of skin irritation or other toxicity. Some patients complained of a moderate burning sensation lasting ten to twenty minutes following irrigations.

#### SUMMARY OF SERIES II

1. In the saline and peroxide group, although healing occurred without deleterious effects, the progress of wounds was, in general, slow.

2. Aqueous iodine irrigations appeared to clean the wounds and a number of them showed progress but this was, in our opinion, of moderate proportions.

3. With azochloramid the discharge in most cases cleared up following irrigations but the wounds did not show the improvement for which we had hoped.

4. With Heliogen irrigations the results confirmed those of the initial series. The odor and discharge of wounds cleared up rapidly and the wounds either healed completely or showed decided improvement.

#### SERIES III: CONTROLLED GROUP

*Powders and Hypertonic Soaks.* Cases were selected and assigned as in Series II. Before application of the powders, the wounds were irrigated with Ringer's solution. With both powders and soaks, wounds were covered with vaseline gauze



except in cases in which it appeared to interfere with the action of Heliogen powder. The substances were: (1) sterilized buffered sulfanilamide powder, ten cases; (2) sterilized sodium sulfadiazine powder, ten cases; (3) sterilized saturated solution of sodium sulfate, ten cases; (4) Heliogen powder, ten cases.

*Buffered Sulfanilamide.* Buffered sulfanilamide was used in the first group of cases because recent studies by Schmelkes et al.<sup>2</sup> and Fox and Rose<sup>3</sup> had shown that buffering increased the absorption of the sulfonamides.\* The amount of powder used was dependent upon the size of the wound, varying from 0.5 to 5.0 Gm. The average blood level twenty-four hours after application of the powder was 0.74 mg. per cent, the highest being 4.0 and the lowest 0.1.

Of the ten cases in this group, two patients expired from extraneous causes. In Case 71 a fifty year old diabetic had an infected postoperative wound which was treated with buffered sulfanilamide. The patient expired in shock the fifth day from general peritonitis, probably due to a rupture of the bowel. Case 67 was a fifty-six year old diabetic. A necrotic area due to cellulitis was excised and the wound treated unsuccessfully with various types of therapy, i.e., hydrogen peroxide irrigations with sulfathiazole powder, Ringer's solution irrigations with buffered sulfanilamide powder, Ringer's solution irrigations with sodium sulfadiazine powder, Ringer's solution irrigations with Heliogen powder and Heliogen solution irrigations with Heliogen powder. Wound edges were then approximated and the wound disturbed only once in every four or five days for irrigations with Heliogen followed by Heliogen powder. After eleven days of this treatment the wound had decreased in size and was beginning to heal. Two days later the patient died from jaundice brought on by some intestinal crisis.

Of the other eight cases, one wound failed to progress (Case 63) and one im-

proved only slightly (Case 95). These were transferred to Heliogen therapy with subsequent improvement. Three wounds showed initial progress under buffered sulfanilamide but then became static (Cases 79, 83 and 87). Under Heliogen therapy progress was observed in all three cases. Of the three remaining wounds, one (Case 75) showed marked improvement on discharge, one was practically healed (Case 99) and one was completely healed (Case 91). In the last case only diphtheroids were cultured.

In summary, the majority of the wounds treated failed to show the expected favorable response so much so that six out of the ten cases were transferred to other forms of therapy. Although the wounds remained clean, progress after a certain period stopped or was too slow. This buffered sulfanilamide was poorly absorbed as evidenced by the amount of powder found in the wounds at each dressing and by the low blood levels. In one instance, (Case 63) a maculopapular eruption appeared during the twenty-four-hour period after a single application of sodium sulfadiazine and seemed to be a delayed reaction to sulfanilamide which had previously been administered for nine days. The blood level had not risen above 0.7 mg. per cent.

*Sodium Sulfadiazine.\** The amount of sodium sulfadiazine used varied from 0.5 to 5.0 Gm. depending on the size of the wounds. The drug was readily absorbed. Twenty-four hours after application no powder was visible in the wounds and the average blood titer was 1.49 mg. per cent, the highest being 7.30 and the lowest 0.1. Because of the high absorption, the drug was discontinued as early as possible.

Of the ten patients treated with this therapy, one wound failed to show any response. In Case 68 the patient was a fifty-two year old diabetic with an infected amputation stump. The wound showed no response to ten days' treatment with sodium sulfadiazine or to six days'

\* Sterilized sulfanilamide buffered with  $\text{CaCO}_3$  was supplied by Wallace and Tiernan Company.

\* The sodium sulfadiazine was supplied by Lederle Laboratories.

Heliogen powder therapy. All treatment was discontinued.

Two wounds (Cases 72 and 88) showed marked improvement with sodium sulfadiazine which was discontinued because of its high absorption since it was expected that healing would continue with dry dressings or with Ringer's solution. Both wounds remained static and Heliogen was substituted and continued until healing was complete.

One wound required surgical revision. In Case 76 an infected appendectomy wound was treated with sodium sulfadiazine for twenty-one days. The patient was referred for surgical revision with the wound clean and in good condition. The highest blood level was 2.26 mg. per cent. The patient was lost to follow-up.

Wounds in the remaining six cases healed completely or showed marked improvement. In the three cases which were followed to complete healing (Cases 80, 92 and 100) the wounds were treated with dry dressings or irrigated with Ringer's solution for periods from two to twenty-five days after discontinuance of sodium sulfadiazine before healing was complete.

In general wounds treated with sodium sulfadiazine progressed rapidly and satisfactorily and the results of this therapy far surpassed those from the buffered sulfanilamide. There was no evidence of drug reaction or local irritation in the ten patients treated. The patients complained of a moderate burning sensation lasting about fifteen minutes after application.

*Sodium Sulfate Soaks.* The wounds were treated with continuous wet dressings of a saturated solution of sodium sulphate. A thin strip of vaseline gauze was placed immediately over the wound and the wet dressing was applied every twenty-four hours. Additional protective coverings were employed to keep the dressings moist.

In this group of ten cases one patient expired. Case 78 was a fifty year old diabetic with a chronic undermining ulcer of two months' duration. After eight days of sodium sulfate therapy healing was pro-

gressing rapidly when the patient died from heart failure.

One case showed an extension of the decubitus ulcer after initial improvement. The patient in Case 66 was a sixty-seven year old diabetic with a decubitus ulcer of the sacral region and a superficially infected amputation stump. After nine days of sodium sulfate therapy the decubitus ulcer began to fill in with healthy granulations and then extension began. Heliogen irrigations and powder were used for seven days but the ulcer continued to spread although *Pseudomonas aeruginosa* disappeared the fifth day. The stump was irrigated for twelve days with Lugol's solution, with slight improvement. Treatment was changed to Heliogen irrigations for six days but the wound continued to discharge. All therapy was discontinued and the patient was discharged.

In one instance additional surgery was required. The patient (Case 74) had a breast abscess which was 9 cm. deep. After seventeen days of sodium sulfate therapy the wound was 50 per cent healed but showed need for further surgery. The patient was referred for the operation and lost to follow-up.

One patient (Case 90) showed improvement under sodium sulfate but the granulations appeared boggy. They became healthy under Heliogen irrigations and the wound decreased about 50 per cent. The patient was referred for secondary closure. Wounds in the remaining six cases healed completely or showed marked improvement.

In deep wounds such as those in Cases 74 and 82 there was particular success in filling the cavity with granulating tissue. However, in shallow, clean wounds as in Cases 86 and 93 granulating areas level with the surface seemed to progress slowly. In three instances (Cases 86, 90, and 70) there was evidence of excessive or abnormal granulations. One case (90) of skin irritation was observed. A moderate burning sensation was experienced for fifteen to twenty minutes following the application

of the first pack. This dressing is not always practical or convenient; in certain parts of the body it is impossible to maintain adequate coverage without considerable discomfort to the patient.

*Heliogen Powder.* The Heliogen powder used for dry application has a lower iodine concentration than the preparation used in irrigating wounds. The concentration of iodine was chosen on the basis of toxicity tests and the results of *in vitro* tests in which no coagulation of protein occurred. This concentration was shown to be bactericidal. The powder is readily soluble in body fluids and does not cake in the wounds. If, however, the lesion is too dry to dissolve all of the powder, it forms a protective film under which healing can proceed. The bactericidal efficiency of Heliogen is not greatly diminished in the presence of organic material.

Of the ten cases in this group, two patients expired with no appreciable improvement in the wounds. Case 44 was a grossly infected abscess of the abdominal wall. The patient remained comatose or semi-comatose following the operation and expired the thirteenth postoperative day with the wound slightly improved. The patient in Case 101 was a seventy-three year old diabetic with a gangrenous appendix. The postoperative wound was treated with Heliogen powder. On two occasions following operation there was temporary paralysis of the right leg. The patient expired on the fourteenth postoperative day from a cerebral accident with no essential improvement in the wound.

In one instance (Case 97) Heliogen was replaced in an effort to eliminate persistent organisms but the original therapy was resumed. Although the wound was contracting rapidly, the organisms persisted and Heliogen powder was replaced by buffered sulfanilamide. The organisms were eliminated but in three days a severe drug reaction developed and Heliogen powder therapy was resumed. The wound proved to need additional drainage and the pa-

tient was referred for the necessary surgery and was lost to follow-up.

The other seven wounds healed completely or showed marked progress with Heliogen powder therapy. One of these cases presented a particularly difficult problem. In Case 65 the patient was eighty years old and had diabetes mellitus and arteriosclerotic heart disease. Following an umbilical herniorrhaphy the wound became infected with hemolytic staphylococcus aureus. Although the patient's general condition deteriorated, culminating in death, the wound had healed completely under Heliogen powder therapy.

In general the wounds cleared rapidly and progressed satisfactorily with Heliogen powder treatments. In none of the cases in which patients were treated with Heliogen powder was there any evidence of systemic toxicity. One patient (Case 73) showed skin irritation which was possibly but not certainly due to Heliogen. Most patients complained of a moderate burning sensation for about fifteen minutes following application.

#### SUMMARY OF SERIES III

1. Buffered sulfanilamide did not evoke as favorable a response as was hoped. Six cases out of ten were transferred to other forms of therapy to hasten healing.

2. Wounds treated with sodium sulfadiazine healed rapidly in most instances. Because of the high absorption the drug was discontinued as early as possible.

3. Sodium sulfate soaks showed particular success in filling deep wounds with granulations but wounds level with the surface progressed more slowly. Dressings are subject to greater practical difficulties than powders or irrigations.

4. With Heliogen powder most wounds cleared rapidly and responded very satisfactorily.

#### CHANGES OF THERAPY

A study of the number of substitutions necessary for each therapeutic agent and the progress of the wounds under other treatments may give an indication of the

relative values of the different substances used.

Heliogen therapy was the one usually employed when a substitution was made in any case in which the wound was originally treated with another agent. There were three cases in which a preparation other than Heliogen was used as the replacing therapy. In Case 44, the ulcer treated with aqueous iodine became worse so the patient was discharged on gelatine paste boot and subsequently improved. In Case 27 azochloramid cleaned the wound but because of severe pain the treatment was changed to normal saline. Complete healing followed. The wound in Case 47 showed only slight improvement with azochloramid but healed completely with hot Sitz baths.

Although Heliogen was substituted for saline and peroxide in Case 42, this was not evaluated because the patient's failure to cooperate made further treatments futile. Case 35 was not significant because although Heliogen was substituted for azochloramid for a single day during the course of treatment, the original therapy was immediately resumed.

In order to evaluate the data more accurately we are summarizing the clinical records of these substitution cases beginning with those preparations which appeared less effective.

*Compound Solution of Iodine.* Heliogen therapy replaced the aqueous iodine irrigations in four of ten cases. However, the wound in Case 60 had inadequate drainage and the patient's condition precluded operation.

In Case 40 with daily foot soaks in diluted Lugol's solution for nine days there was improvement in the swelling but none in the discharge. After daily Heliogen foot soaks were started, the swelling and discharge decreased rapidly. Remnants of the nails which acted as foreign bodies prevented complete healing. The necessary surgery was performed and subsequently complete healing occurred under Heliogen therapy. It should be noted that improvement began under Heliogen treatments

before the removal of the nail remnants. In Case 32 the wound was treated with Lugol's solution for forty-seven days but did not appear to be making any more progress. Heliogen therapy was begun and the wound healed uneventfully twelve days later. In Case 56 the wound was irrigated with Lugol's solution, full strength, for three days and then with half strength for six days. Heliogen treatments were started because there was no formation of new granulations. In three days the wound was much cleaner but five days later the case was lost to follow-up. In the three preceding cases one wound healed and two improved after the change to Heliogen irrigations.

*Azochloramid.* Heliogen was substituted for azochloramid in four of ten cases. However, in Case 43 osteomyelitis was found deep in the pelvis.

In Case 39 a recurrent superficial ulcer had not progressed with wet soaks, gentian violet and scarlet ointment during three months. After admission to the series practically no progress occurred in one week of daily irrigations with azochloramid but under Heliogen irrigations the wound healed completely in twenty-two days. The wound in Case 55 was packed with sulfathiazole for two days after excision of a carbuncle. During six days of subsequent azochloramid therapy there was no improvement so Heliogen irrigations were started. In twelve days the wound had decreased from 8 to 6½ cm. and the granulations were clear and appeared healthy. In Case 51 the wound was an atrophic type of ulcer, recurrent over fifty years on a sixty-nine year old patient. This lesion had increased in size over a period of two to three years under treatment with gentian violet and boric acid salve. After three days of azochloramid therapy the wound seemed worse, but with Heliogen irrigations (sixty-eight days) the base of the ulcer filled in with bright pink granulations. While epithelium did not grow, a successful skin graft was accomplished. Of the three preceding cases two wounds

healed completely and one showed marked progress after Heliogen therapy was begun.

*Buffered Sulfanilamide.* Six of ten cases were changed to Heliogen therapy from buffered sulfanilamide. However, one case was inconclusive (Case 67). Several therapies including sulfanilamide, sulfadiazine and Heliogen were tried; but although the wound appeared clean, it did not progress. Improvement occurred when the wound was disturbed only once in four or five days for Heliogen irrigations followed by Heliogen powder.

In two instances (Cases 79 and 83) wounds which had been slow or stationary in forming granulations or epithelium under buffered sulfanilamide progressed satisfactorily under Heliogen therapy. In Case 79 after fifteen days of buffered sulfanilamide, eight days of dry dressings and six days of sulfanilamide, a small portion of the granulating area had still failed to epithelize. Heliogen irrigations were started and in seventeen days healing was complete. In Case 83 after twenty-two days of buffered sulfanilamide treatments and six days of dry dressings a small opening in the granulations had failed to fill in. Heliogen powder therapy was started and in ten days healing was complete.

In three cases the wounds progressed under Heliogen therapy whereas they had not materially improved under buffered sulfanilamide. The superficial decubitus ulcer in Case 63 showed some progress after nine days' treatment with buffered sulfanilamide but because improvement was not considered satisfactory, sodium sulfadiazine was started. A rash developed, probably a delayed reaction to sulfanilamide. Heliogen irrigations were begun and after nine days the wound was 25 per cent smaller. In Case 87 the wound, 7 cm. deep and 1 cm. in diameter, had decreased a maximum of 25 per cent during ten days' treatment with sulfanilamide. In fourteen days of Heliogen therapy which followed, the wound healed completely. The wound in Case 95 still had a profuse yellow-brown discharge and only a few small areas

showed the formation of granulations after eleven days of buffered sulfanilamide. Heliogen irrigations were started. In seven days the discharge was considerably less and in a total of thirty-three days of Heliogen therapy the wound had decreased in size 75 per cent. Of the five preceding cases one healed completely, two improved, one wound formed granulations and one formed epithelium under Heliogen treatments.

*Sodium Sulfadiazine.* Of the ten cases in this group three patients were transferred to Heliogen therapy. However, in Case 68 the wound was an infected mid-thigh amputation stump on a fifty-two year old diabetic. No progress occurred with either therapy.

In Case 72 the wound was treated with sodium sulfadiazine and was so improved after sixteen days that the drug was discontinued (because of its high absorption) in favor of irrigations with Ringer's solution and dry dressings. Fourteen days later, however, satisfactory progress had not been maintained and Heliogen irrigations were started. While the wound healed completely under Heliogen therapy, progress has also occurred with sodium sulfadiazine. Case 88 followed a similar course. Under sodium sulfadiazine therapy the wound contracted 40 per cent in nine days when the drug was discontinued because of its high absorption. Ringer's solution irrigations and dry dressings were used for ten days but the wound remained the same. Heliogen powder applications were begun and in eight days the wound was 80 per cent healed. Fourteen days later healing was complete on daily hot baths. As in the preceding case the wound improved under both Heliogen powder and sodium sulfadiazine. Of the three cases changed from sodium sulfadiazine to Heliogen therapy, one wound did not improve with either treatment and two wounds progressed under both preparations.

*Saturated Sodium Sulfate.* Of the ten patients treated with saturated sodium sulfate, two were transferred to Heliogen

therapy. However, in one of these (Case 66) an elderly diabetic with arteriosclerotic heart disease, an infected amputation stump and a decubitus ulcer of the back offered an extremely poor prognosis regardless of the type of treatment.

In Case 90 the wound was first treated with saline and peroxide for eight days with no improvement. After twelve days of sodium sulfate soaks granulations were beginning to fill in but appeared boggy, the wound was still discharging a purulent exudate and the adjacent skin showed evidence of marked irritation. After seven days of Heliogen irrigations the granulations were more satisfactory in appearance; ten days later epithelization was progressing. The patient was discharged on dry dressings and was re-admitted one week later for a secondary closure as the wound had not progressed further on dry dressings. In the preceding case the wound improved under Heliogen therapy whereas progress under sodium sulfate soaks had not been satisfactory.

*Heliogen Solution.* Of the twenty-three patients treated with Heliogen irrigations (thirteen in the preliminary series and ten in Series II) only one (Case 20) was changed to another therapy. However, in this case the patient was sixty-four years old and her condition was complicated with anemia of undetermined nature and uterine fibromyomas. The wound was a huge, discharging ulcer of the back of three years' duration. The spinal processes of the lumbar vertebrae were involved. The lesion was treated with Heliogen irrigations, then with saline and peroxide irrigations in conjunction with sulfanilamide and again with Heliogen. No essential progress was noted with any therapy. The patient was discharged on her own request.

*Heliogen Powder.* Of the ten patients treated with Heliogen powder, one (Case 97) was transferred to other therapy. In this case the wound was treated with Heliogen powder for twenty-five days. The wound contracted rapidly but the organisms persisted and treatment was changed

to buffered sulfanilamide. The organisms were no longer recovered but the patient showed a strong drug reaction and Heliogen was resumed. Hemolytic streptococcus was again cultured. The wound proved to need additional drainage; the patient was referred for the necessary surgery and was lost to follow-up.

#### SUMMARY OF CHANGES OF THERAPY

An examination of the changes in therapy brings out four points:

1. Of the nineteen cases in which Heliogen replaced the original therapy, fifteen patients progressed under Heliogen treatments. In the remaining four cases improvement was not observed with either therapy.

2. Of the forty-one patients treated with Heliogen, change of therapy was considered advisable in only two cases. In both instances they failed to improve after substitution. This group of cases includes Series I in which there was a larger proportion of chronically infected wounds and of advanced adverse systemic conditions.

3. With four of the eight therapeutic agents used, wound progress was sufficiently satisfactory in all or nearly all of the cases so that change of therapy was unnecessary. These agents were saline and peroxide, saturated sodium sulfate, sodium sulfadiazine and Heliogen, in both solution and powder form.

4. The data indicate that three of the substances used appeared to be less effective than the others. These were compound solution of iodine, azochloramid and buffered sulfanilamide.

#### COMPARISON OF RESULTS

We are cognizant of the inherent difficulties peculiar to any clinical investigation, some of which are as follows: (1) A particular wound might have progressed more rapidly under some other therapy than the one originally tried. (2) When a change of therapy results in better progress, the improvement cannot be at-

tributed with certainty to the effect of the new treatment because the change itself may stimulate the natural restorative processes. (3) Some wounds may be expected to heal completely without any local therapy whatsoever. (4) There are variables associated with any clinical study such as the differences in the area and depth of wounds, the variations in degree and nature of the infections and in the ages and systemic conditions of the patients. (5) From the data it can be seen that there was great variation in the bacterial flora of the wounds. Only two organisms were cultured in the majority of cases. Hemolytic staphylococcus aureus and hemolytic streptococcus.

However, even with these organisms two factors lead us to believe that it is not helpful to compare the elimination of bacteria under different therapeutic agents with respect either to the number of times they were eliminated or the number of days required for elimination. These factors are (1) the relatively small number of patients treated with any one therapeutic agent and (2) the variables in the wounds and in the systemic conditions of the patients. Unless comparison can be made between wounds of at least approximately the same size and type, infected to the same degree with the same organisms, and unless the patients' systemic conditions are comparable, the elimination of organisms is obviously an unfair basis of comparison. These conditions were not present in this study.

Because the conditions of this study precluded a significantly accurate count, no quantitative study of the bacterial flora of wound surfaces was made. Present methods of taking bacterial counts from wound surfaces give at best only an approximation of the number of organisms present. In addition, no technic is available for the quantitative estimation of bacteria deep within tissues; our clinical cases involved a number of such wounds.

For the reasons outlined we have not used the elimination of bacteria as one of the criteria in attempting to evaluate the

relative efficacies of the substances used in treatments.

The relatively small number of cases included in this study precludes the statistical evaluation of the results in such a way that the effect of uncontrollable variables would be reduced to a minimum. Accordingly, the conclusions drawn from this investigation cannot be taken as absolute or final but we believe there is sufficient evidence as to the merits of the preparations studied to warrant presenting the comparisons and conclusions as indications of what may be expected.

The relative values of the different therapeutic agents with respect to the progress of the wounds and the toxicity are listed. Comparisons are made only between Heliogen and the other preparations used. When both substances have the same property to a like degree, this is omitted from the comparisons.

*Aqueous Iodine.* Wound progress with Heliogen irrigations appeared to be more satisfactory than with compound solution of iodine. With aqueous iodine one patient of ten showed skin irritation while none of the twenty-three patients treated with Heliogen solution gave evidence of any toxicity.

*Azochloramid.* Healing with Heliogen irrigation therapy was more satisfactory than with azochloramid. In addition, three patients of ten showed local toxicity under azochloramid treatments while none of the twenty-three patients on whom Heliogen was used showed any toxicity. This is more noteworthy as some exceptionally difficult wounds in the Heliogen group required treatment for long periods of time.

*Saline and Peroxide.* Wound progress was satisfactory with both saline and peroxide and with Heliogen irrigations although with saline and peroxide wound healing was generally slow; four patients of ten required additional treatment such as saline irrigations to make the wound heal completely. Heliogen solution is bactericidal while treatment with saline and peroxide is only slightly inhibitory.

*Buffered Sulfanilamide.* The progress of wounds appeared to be much more satisfactory under Heliogen therapy than with this particular buffered sulfanilamide. One patient of ten showed a drug reaction to sulfonamide and one patient of ten showed skin irritation possibly due to Heliogen.

*Sodium Sulfadiazine.* With both sodium sulfadiazine and Heliogen powder wound progress was very satisfactory. It would be difficult to choose either preparation to the exclusion of the other. Under sodium sulfadiazine therapy there is an ever-present possibility of a drug reaction so that blood levels and kidney function must be constantly watched.<sup>4,5</sup> Heliogen powder appears to be without danger of systemic toxicity although in one patient of ten there was a skin irritation possibly due to Heliogen.

*Sodium Sulfate Soaks.* Progress of deep wounds seemed to be equally satisfactory with Heliogen and with sodium sulfate soaks up to the point when epithelium began to form. Shallow wounds progressed more satisfactorily with Heliogen. The sodium sulfate dressing is not always practical and in some parts of the body can be used only with considerable discomfort. Heliogen powder therapy is without this disadvantage. Sodium sulfate is neither bacteriostatic nor bactericidal while Heliogen is bactericidal.

#### CONCLUSIONS

In so far as results can be evaluated from the limited number of cases, it appears that (1) Heliogen, under the conditions

used in this study, is not toxic, (2) it is successful in clearing up the odor and discharge of infected wounds with free drainage; and (3) wounds, including those chronically infected which had remained static under various therapies, responded favorably to Heliogen.

We suggest that Heliogen may prove to be a valuable addition to the chemotherapeutic agents used in the treatment of wounds.

*Acknowledgments:* The cooperation and assistance of the Surgical Service of the Kings County Hospital was enjoyed during this study. We sincerely appreciate the invaluable criticisms and cooperation of Professor Arthur C. DeGraff, New York University College of Medicine, and Professor Ralph H. Müller, Washington Square College, New York University, throughout the investigation. We are very grateful to Dr. J. A. Curran, Dr. Robert F. Barber and Dr. Wade W. Oliver for their valuable advice and interest. We also wish to thank Miss Mary Ann O'Shea and Miss Olive Jorgensen for their technical assistance; Mr. Steve Montes for the photography; Mrs. Agnes Ryan, R. N.; and Miss Catherine Johnson as recorder.

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# PRIMARY RESECTION AND ASEPTIC ANASTOMOSIS FOR LESIONS OF THE COLON\*

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AFTER resecting lesions of the colon the surgeon may immediately re-establish bowel continuity or may elect to delay the anastomosis using some modification of the Mikulicz procedure. Primary resection of lesions of the colon and aseptic anastomosis have become increasingly popular in the last few years. This is due to a number of factors among which are: greater use of the Wangenstein and Miller-Abbott tubes, development of antibiotics and colon antiseptics, better knowledge of the preoperative preparation of patients, refinements in anesthesia and surgical technic and use of blood and plasma. Increasing familiarity with the procedure has added to its safety. Other less scientific reasons for doing primary resections are: avoidance of multiple operations and decrease in hospital days. These, of course, only become important if the safety of the procedure is established.

There is common agreement among surgeons that primary resection offers wide removal of the lesion and its mesentery in addition to the advantages just mentioned. For a long period of time primary intraperitoneal anastomosis of the colon was avoided because it was dangerous. The earliest attempts to treat carcinoma of the colon surgically were crude attempts at resection and immediate anastomosis—usually open. With no preparation, usually in the face of obstruction, with debilitated patients and without antibiotics and other surgical adjuvants, the results were disastrous. As Wangenstein<sup>14</sup> points out surgery was not yet ready for primary resection. With the development of the exteriorization principle by Mikulicz and others, the subsequent drop in mortality figures fol-

lowed. Because of the inauspicious start made by primary resection and anastomosis, there has been an understandable reluctance on the part of surgeons to accept this procedure. It is our purpose in this paper to report briefly our experiences with primary resection and aseptic anastomoses of the colon.

## PREOPERATIVE PREPARATION

Preoperative treatment of the patients in this series might properly be considered under three headings: (1) General considerations; (2) management of the unobstructed case and (3) management of the obstructed case.

*General Considerations.* Many of these patients exhibited chemical imbalances, vitamin deficiencies, anemias and hypoproteinemia. Efforts were concentrated on correcting these states by use of whole blood transfusions, vitamins, liberal high protein diets and parenteral fluids including amino acids when indicated. Wherever and whenever possible the patients were kept ambulatory until just before definitive surgery was done.

*Management of the Unobstructed Case.* These patients were placed on a high caloric, high vitamin, high protein, low residue diet. The colon was prepared using daily enemas and saline catharsis with Fleet's Phospho-Soda, 2 dr. at 9 and 11 A.M. They were started on sulfasuxidine with an initial dose of 3 to 4 Gm. and then 2 Gm. every four hours. We found that with seven to ten days of such preparation the colon was bacteriologically and physically ready for surgery. Many surgeons prefer to use sulfathalidine as a colon antiseptic and there is little question that it is equally

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as effective as sulfasuxidine. On occasion, sulfasuxidine will cause mild to moderate diarrhea but we have never encountered a reaction severe enough to cause us to discontinue it. Indeed we believe that this mild diarrhetic effect is advantageous and helps in the preparation of the colon. We believe that the actual mechanical cleansing of the colon is more important than use of the colon antiseptics. Much of this portion of the preoperative management of these patients was carried out on an ambulatory basis outside of the hospital.

*Management of the Obstructed Case.* Obstruction of the colon from right-sided malignant lesions is rarely encountered. This is due to the larger diameter of the right colon, its liquid contents and the nature of the growth. When obstruction of the right colon does exist, it is of serious prognostic import, usually denoting incurability because of marked local extension or widespread metastases. Often decompression can be accomplished by use of the Miller-Abbott tube followed later by low enemas. If after a reasonable trial the obstruction is not relieved, then ileotransverse colostomy is the procedure of choice. After the ileotransverse colostomy has been done the usual preparation is begun and if possible the resection is done as a second stage.

With obstruction in the transverse or descending colon, we prefer cecostomy, using a large bore tube and the technic of Lockhart-Mummery.<sup>8</sup> In our experience this procedure has proved to be most satisfactory. The size of the lumen of this tube is very important and we have found that a tube with a lumen diameter measuring 0.75 cm. is ideal. We find that it furnishes adequate, immediate, safe decompression and the fistula closes rapidly once the tube is removed. We irrigate the cecostomy tube with tepid water daily, beginning irrigations in about forty-eight hours. We have, on occasion, used a saturated solution of sulfasuxidine instilling it through the tube following irrigation. Often the edema about the lesion subsides and the obstruction is relieved enough to allow the

irrigation to pass per rectum. We have found the average obstructed case requiring cecostomy will need from ten to fourteen days to decompress adequately the colon and condition the patient for further definitive surgery. The cecostomy does not

TABLE I

Nature of Lesions	No. of Cases	Deaths
Carcinoma.....	38	0
Ileocectitis.....	4	0
Lymposarcoma of the cecum.....	1	0
Tuberculosis of the cecum.....	1	0
Carcinoid of the terminal ileum....	1	0
Lipoma of the cecum.....	1	0
Diverticulitis of the cecum.....	1	0
Carcinoid of the transverse colon with jejunocolic fistula.....	1	0
Total.....	48	0

and should not prevent ambulation before the final procedure. There are many who advocate the use of transverse colostomy in this situation and we certainly have no quarrel with them. However, the patient is then committed to another operative procedure.

All patients with lesions of the cecum or ascending colon come to the operating room with a Miller-Abbott tube in place. Patients with lesions elsewhere in the colon have an inlying gastric tube. For these it has been our policy to do a cecostomy at the time of resection, if one had not already been done, because often the ileocecal valve prevents effective decompression by the Miller-Abbott tube.

#### NATURE AND LOCATION OF LESIONS

A glance at Table I shows that the majority of resections were undertaken for carcinoma. Among the lesions of the right colon there were four cases of ileocectitis in which we elected resection of the terminal ileum and right colon. One patient had tuberculosis of the cecum necessitating resection. One patient had a carcinoid of the terminal ileum with metastases to the liver. The local lesion was resected and the

patient is alive and working every day eighteen months following operation. There was one case of lymphosarcoma and one lipoma of the cecum. One patient, an eighty-seven year old male, was operated on for acute appendicitis and was found

with a Miller-Abbott tube in place and functioning.

In seven cases of unrelieved obstruction it was necessary to do a preliminary cecostomy as a first-stage procedure followed at a later date by resection and anastomosis.

TABLE II

Location of the Lesions	No. of Cases
Cecum and ascending colon.....	25
Transverse colon.....	6
Splenic flexure.....	7
Descending colon.....	4
Sigmoid colon.....	6
Total.....	48

to have a mass involving the cecum but not the appendix. This was resected without preparation under the impression we were dealing with a carcinoma. Pathologically it proved to be a large diverticulum of the cecum. The mass consisted of dense inflammatory tissue surrounding the fecolith-filled diverticulum. This patient made a remarkable recovery. He was discharged as ambulatory from the hospital on his eighth postoperative day. There were no deaths in this series.

A study of Table II reveals that the majority of lesions for which aseptic anastomosis was done were proximal to the sigmoid colon. In our opinion this technic is not applicable to most lesions of the sigmoid colon because of the difficulty in applying the clamps and of placing sutures accurately deep in the pelvis. In those lesions of the sigmoid colon which are high enough for anterior resection but too low for the use of this technic we have used open anastomosis with good results.

TYPES OF OPERATIONS

It will be seen from Table III that twelve one-stage resections of the cecum and ascending colon with complementary ileostomy were done. These were done early in the series. Since then we have done thirteen similar resections without ileostomy but utilizing a Miller-Abbott tube. We believe that an ileostomy is unnecessary

TABLE III

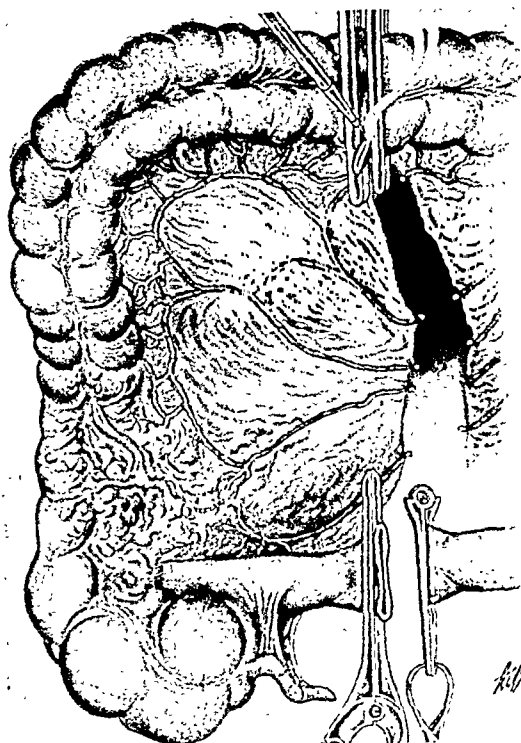
Types of Operations	No. of Cases
One-stage resection of the cecum and ascending colon with ileostomy.....	12
One-stage resection of the cecum and ascending colon without ileostomy.....	13
One-stage resection of the transverse colon with cecostomy.....	4
One-stage resection of the transverse colon without cecostomy.....	2
One-stage resection of the splenic flexure with cecostomy.....	3
Two-stage resection of the splenic flexure with cecostomy, first-stage.....	4
One-stage resection of the descending colon with cecostomy.....	4
One-stage resection of the sigmoid colon with cecostomy.....	3
Two-stage resection of the sigmoid, cecostomy, first-stage.....	3
Total.....	48

It will be seen from Table III that in resection of the transverse, descending and sigmoid colon we have done a complementary cecostomy at the time of operation. We believe that this is a safety measure of merit.

COMPLICATIONS

It was necessary to reoperate upon one patient because of obstruction at the site of the anastomosis. It has been our practice to break in the mucosal diaphragm with the index finger and thumb following completion of the anastomosis. In this case the crushed mucosa had remained sealed and at the second operation an incision was made over the anastomosis longitudinally, the septum was opened and the bowel was closed transversely. The patient made a prompt recovery.

There were four intrabdominal abscesses occurring postoperatively which we believe definitely can be attributed to some technical error resulting in a leak of colonic contents. (Table IV.) All four of these patients developed septic fevers with palpa-



1A\*

FIG. 1. A, shows removal of the primary lesion and the gland-bearing mesentery.

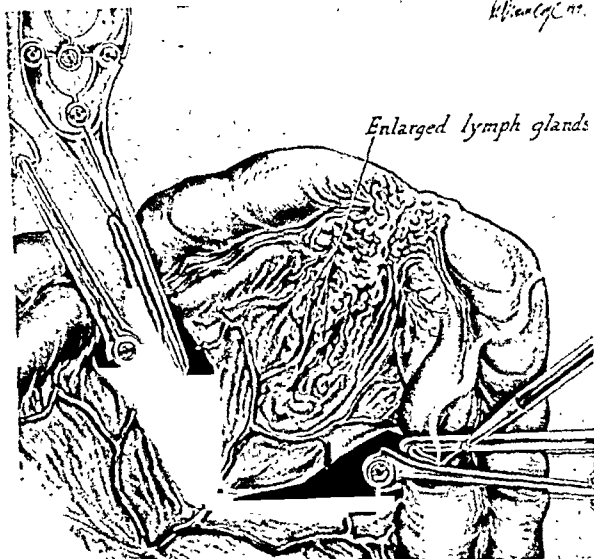
ble, tender, abdominal masses. All were adipose with fat mesenteries, and all instances occurred in resections of the right colon. It was necessary in one case to drain two abscesses through the abdominal wall. The other three patients ran remarkably

TABLE IV

Complications	No. of Cases
Intra-abdominal abscess.....	4
Obstruction at the site of the anastomosis.....	1
Wound infection at the site of the ileostomy.....	1
Wound infection at the site of the cecostomy wound.....	1
Wound infection.....	1
Cystitis.....	4
Pneumonia.....	1
Wound dehiscence.....	1

similar courses. Each ran a septic fever with a palpable non-pointing intra-abdominal mass. Subsequently, each had several very loose, foul stools containing pus, following which their temperatures rapidly returned to normal and the masses disappeared. Three of these patients had both

\* Figs. 1A, 2A, 3A, 4A and 5A show the procedure for lesions of the right colon.



1B†

FIG. 1. B, removal of the primary tumor with the gland-bearing mesentery; blood vessels have been tied.

penicillin and sulfadiazine postoperatively. One patient had neither and ran essentially the same course. There was one wound dehiscence in this series.

The other complications were of a minor nature. We had no thrombophlebitis or recognized phlebothrombosis in this series although the average age was fifty-five years.

#### POSTOPERATIVE CARE

At the time of operation all patients were given whole blood transfusions. All patients received blood postoperatively when needed. Most patients were placed in oxygen immediately after operation. Fluid balance was maintained using intravenous fluids. Plasma proteins were maintained as well as possible, using whole blood, plasma and parenteral amino acids. A particular effort was made to prevent postoperative pulmonary complications. The patients were moved frequently and encouraged to breathe deeply and to cough when necessary. In addition, at the first evidence of mucous in the air ways which the patient was unable to expectorate, we used intra-

† Figs. 1B, 2B, 3B, 4B and 5B show procedure for lesions in the transverse, descending and sigmoid colons.

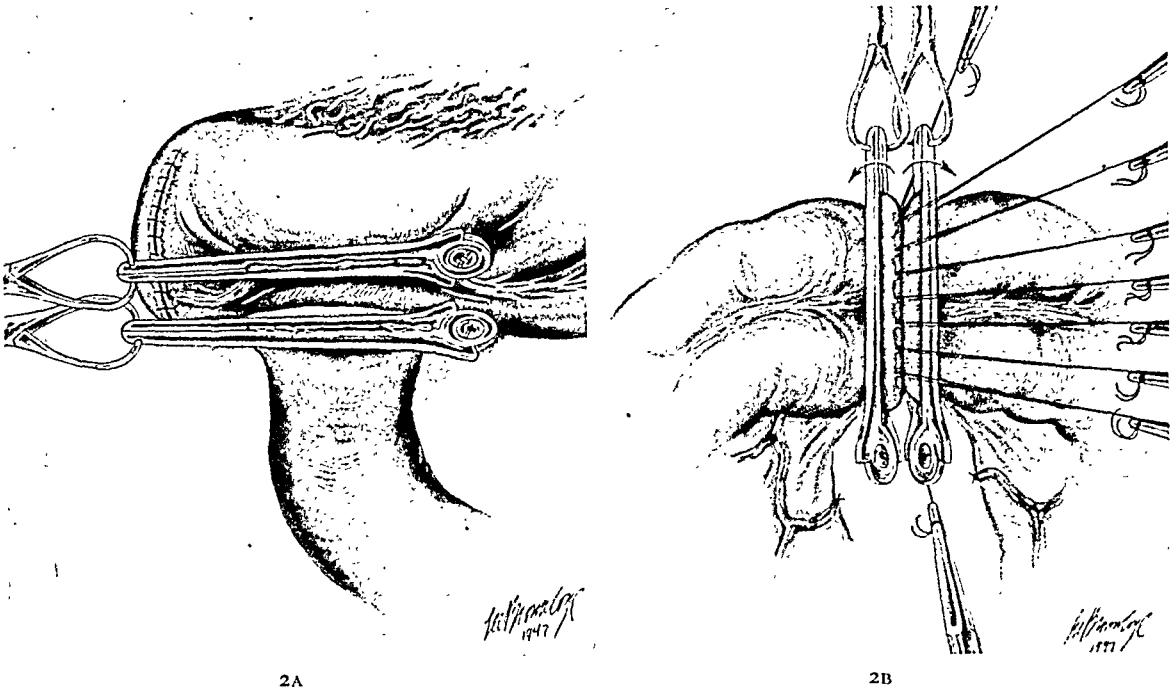


FIG. 2. A, the end of transverse colon has been closed and the portion of transverse colon to be used for anastomosis with ileum has been clamped with a Stone clamp and the bowel wall cut away; B, Stone clamps rotated outward; posterior serosal sutures in place.

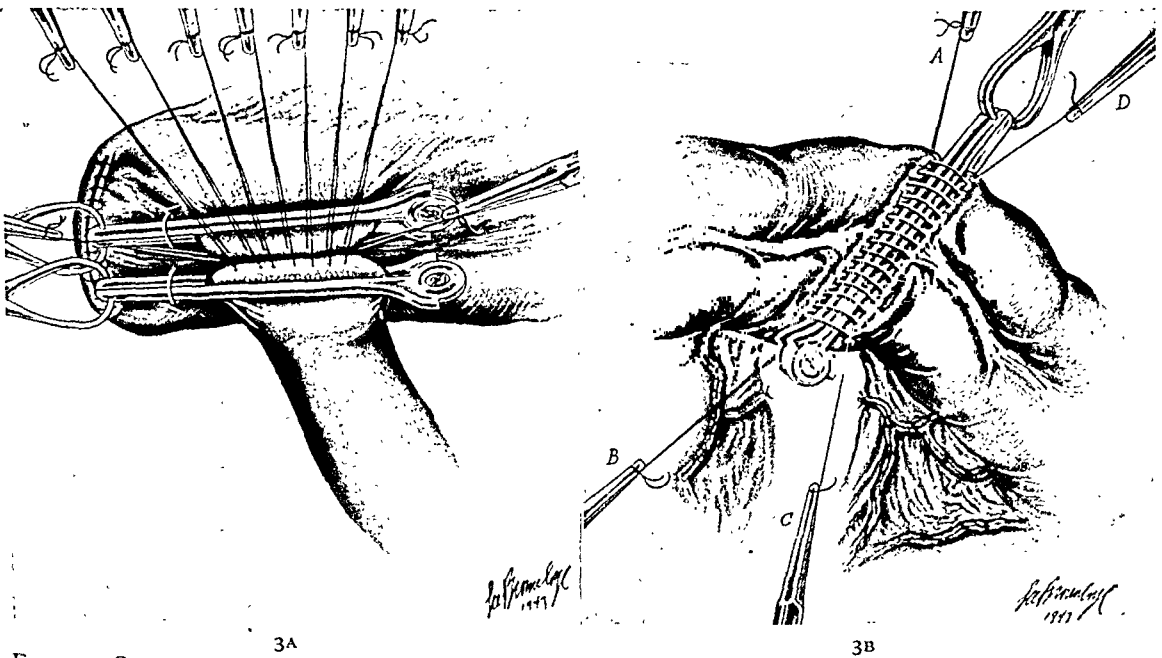
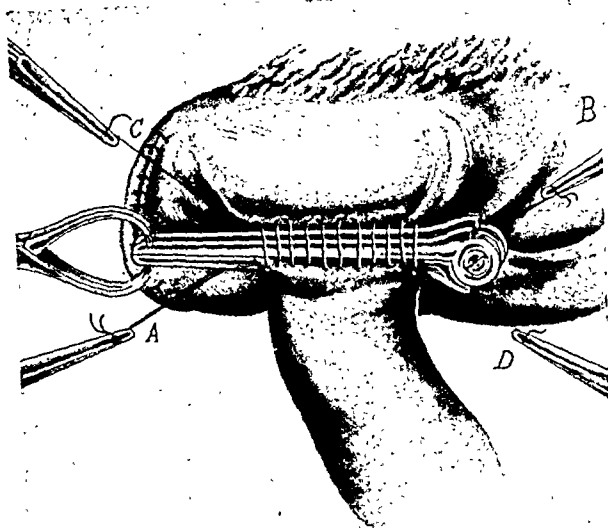
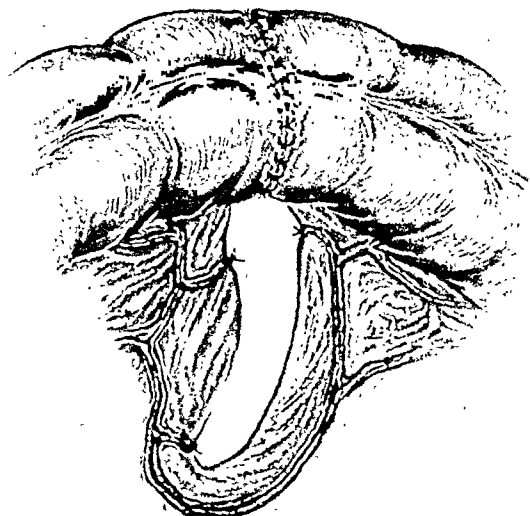


FIG. 3. A, Stone clamps rotated outward and posterior serosal silk sutures in place but not tied; B, running sero-muscular basting suture (C and D) of No. 00 chromic; end posterior serosal sutures (A and B).

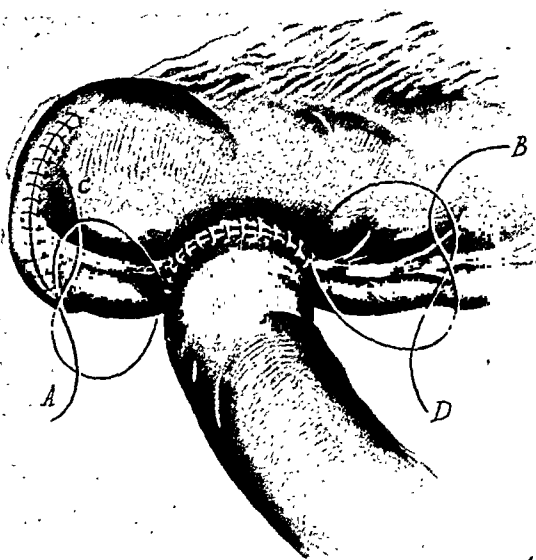


4A

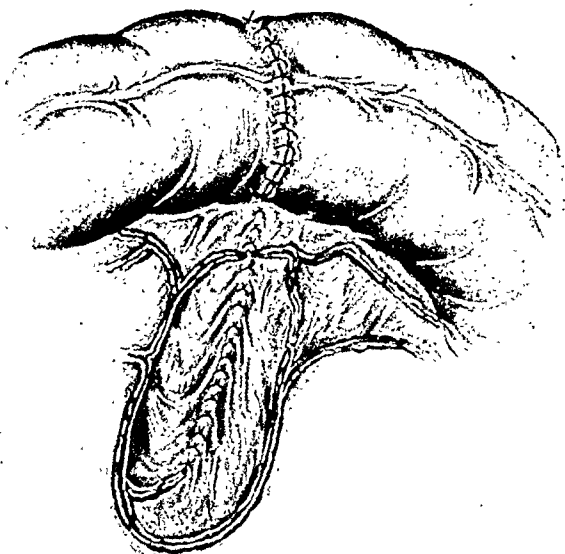


4B

FIG. 4. A, posterior and serosal sutures (A and B); running basting seromuscular suture (C and D) of No. 00 chromic which has been taken over the Stone clamps; the clamps are now ready to be removed; B, clamps have been removed; anastomosis is completed and rent in mesentery is to be closed.



5A



5B

FIG. 5. A, shows the clamps removed and the ends of the running chromic suture being tied to the end posterior serosal sutures; B, rent in mesentery closed with sutures of fine silk.

tracheal suction with a soft rubber catheter. Foot exercises were daily routine.

Since the advent of penicillin we have used it routinely postoperatively for the first forty-eight to seventy-two hours. We believe that it will reduce the numbers

and severity of pulmonary and urinary complications.

Intragastric or intra-intestinal suction was maintained until the patient passed gas per rectum. This usually occurred at seventy-two hours. Following this the tube

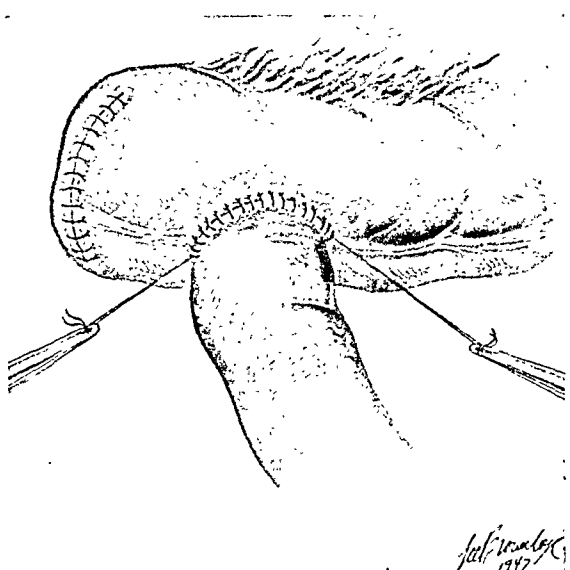


FIG. 6. Completion of anastomosis anteriorly with interrupted serosal sutures of C silk. A similar posterior layer is applied after rotating the bowel.

was removed and the patient started on liquids proceeding as rapidly as possible to a full nourishing diet.

We allowed the patients to be up as soon as was practical. Most of them were ambulatory by the fifth postoperative day. If cecostomy had been done as a first-stage procedure, then the tube was removed after their first normal bowel movement. If the cecostomy was done at the time of operation as a complementary procedure, then the tube was left in place about twelve days before attempting removal. This period of time is needed to allow softening of the catgut sutures so that tearing of the cecal wall will not occur upon removal of the tube. Following its removal, the cecostomy wound quickly closed. The average stay in the hospital of the patient with the uncomplicated case was 15.5 days and of those with complicated cases 34.0 days. The over-all average hospital stay for the patients in this series was 21.6 days.

#### TECHNIC OF OPERATIVE PROCEDURE FOR LESIONS OF THE RIGHT COLON

The abdomen is opened through a generous right rectus, muscle-splitting incision. Hemostasis is effected with No. 60 cotton ties. Before proceeding with the surgery a

complete exploration of the abdominal contents is made. The cecum and ascending colon are mobilized by cutting their lateral peritoneal attachments. The ureter, spermatic or ovarian vessels, kidney and duodenum are visualized and avoided. The ileocolic artery is tied near its origin from the superior mesenteric artery. When the right colic is present and arises from the superior mesenteric artery it is likewise tied. The ileum is then divided with the cautery between Stone and Payr clamps selecting a site about 10 cm. from the ileocecal valve. The transverse colon is divided with the cautery between Stone and Payr clamps, selecting a site well beyond the lesion and, of course, with an adequate blood supply. A wide portion of the mesentery with the regional lymph nodes is removed with the primary lesion. (Fig. 1A.) The end of the colon is first closed aseptically using a running atraumatic seromuscular suture of No. 00 chromic reinforced with interrupted serosal sutures of C silk. An area on the anterior aspect of the transverse colon near the closed end is then selected and clamped longitudinally with a Stone clamp removing with the cautery a portion of colon approximating the transverse diameter of the ileum. (Fig. 2A.) An aseptic end-to-side ileotransverse colostomy is then done over the Stone clamps. In this series the Stone clamps were used exclusively and proved to be most satisfactory.

The site on the colon is cleaned of fat as carefully as possible and a number of posterior serosal sutures, uniting ileum and colon, are placed but not tied. (Fig. 3A.) When the last stitch is placed, they are then tied and cut leaving the two end sutures long. (Fig. 3A.) A running, basting stitch of No. 00 chromic is then taken over the clamps (Fig. 4A), and while the operator puts gentle traction on the two ends of this suture, the assistant removes the clamps. This procedure inverts the bowel and you are now ready to place the anterior serosal layer. The ends of the chromic basting stitch are then tied into the end pos-

terior serosal stitches (Fig. 5A AC and BD). Inasmuch as the catgut is a running sliding suture, care must be taken at this point not to tie the end sutures too tightly or you will encroach upon the lumen of the bowel. The anterior row of interrupted serosal sutures of C silk are placed and tied. (Fig. 6A.) To reinforce the posterior row and the corners a clamp is passed beneath the anastomosis and the opposite end posterior serosal suture is seized. The bowel is turned by this procedure so that a second layer of posterior serosal sutures of C silk may be taken. The angles are, of course, carefully closed. The anterior layer is reinforced with a few serosal sutures and the rent in the mesentery and mesocolon is closed with a few fine, cautiously placed sutures of C silk.

#### PROCEDURE FOR LESIONS IN THE TRANSVERSE, DESCENDING AND SIGMOID COLONS

In lesions distal to the hepatic flexure we use end-to-end aseptic anastomosis over Stone clamps. Occasionally, despite preliminary decompression, we encountered moderate disparity in the size of the bowel proximal and distal to the lesion. However, we were able in all cases to perform end-to-end anastomosis. We concede that great disparity between the proximal and distal colon would demand side-to-side anastomosis. The principles of technic are exactly the same as in resection of the right colon described in the preceding paragraph. (Figs. 1B, 2B, 3B, 4B and 5B.)

The wounds are closed with interrupted Snead, figure eight, sutures, using as suture material No. 31 stainless steel wire or No. 40 cotton doubled.

#### SUMMARY AND CONCLUSIONS\*

1. Our experience with forty-eight consecutive primary resections of the colon are presented.

\* Since this article was submitted for publication,

2. We believe that with careful preparation of the patient, including medical or surgical decompression of the bowel, aseptic primary resection of the colon is an adequate and safe procedure.

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the authors have operated on four additional patients without mortality.



## PROGRESS IN COLON SURGERY\*

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CONSIDERABLE difference of opinion still exists among the large clinics concerning the operative management of carcinoma of the colon. In 1944 we published the results of our experience with such cases over a five-year period.<sup>1</sup> At that time our procedure of choice in colon resections was the exteriorization operation with delayed anastomosis. It is now ten years since the organization of the surgical gastrointestinal service at the Jewish Hospital of Brooklyn. In the light of surgical progress that has been made since our original report we believe it might be of interest to review again our personal experience with resection of carcinoma of the colon.

It is our purpose in this paper to report upon 115 cases of colon resection for carcinoma (exclusive of carcinoma of the rectum) performed during the years 1938 to 1947, inclusive. For convenience of discussion we have divided this ten-year period into two parts: The early period 1938 to 1944, and the later period 1945 to 1947.

During the seven-year period between 1938 and 1944 a total of sixty-six colon resections for carcinoma were done. Delayed anastomosis was used in fifty-seven instances. The distribution of lesions is noted in Table I. There were fourteen cases of carcinoma of the right colon, thirteen of the transverse colon and thirty left colon lesions. The Lahey modification of the Mikulicz procedure was used in the right colectomies and the transverse and left colon resections were done by the Rankin obstructive method. In this series of fifty-seven cases there were twenty-five wound infections, five eviscerations and four cases of peritonitis. One case of peritonitis was the result of perforation of the

cecum preoperatively, the other three occurred following operation. The average hospital stay, in hospital days, in these cases was 68.8 days. This included the time required for closure of the colostomy. Of these 57 patients eight died, a mortality rate of 14.1 per cent. Peritonitis accounted for four of the deaths; one died of post-operative shock; there were two cardiac deaths and one due to a cerebral accident.

During the same seven-year period (1938 to 1944) primary anastomosis was performed in only nine cases. All of these nine cases were right colectomies and five of these were done in two stages. In this group wound infections occurred in eight instances and peritonitis in two. The average hospital stay for these was 50.7 days. This included the two-stage resections. There were three deaths, a mortality of 33.3 per cent. Peritonitis was the cause of death in two cases, a cerebral accident in one. (Table I.)

In the period from 1945 through 1947 a total of forty-nine colectomies were done. Delayed anastomosis was used in only twelve cases and primary anastomosis was performed in thirty-seven. The distribution of cases is indicated in Table II. Of the delayed anastomoses, one resection was of the right colon and eleven were on the left side. In five of the twelve cases there was a significant degree of obstruction due to the lesion, with proximal distention of the bowel. In two cases there was perforation of the lesion with abscess formation at the time of operation. In the remaining five cases the extensive involvement of malignancy, the length of the procedure and the condition of the patient were such as to make delayed anastomosis the method of choice. In these twelve patients in whom delayed anastomosis was

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done, there was one wound infection, one case of peritonitis and one localized intra-abdominal abscess which drained spontaneously. The average hospital stay for these twelve patients was 43.4 days. There were four deaths in this group, a mortality rate

of the carcinomatous lesion with leakage into the peritoneal cavity. Both of these patients died, and in retrospect it appears that primary anastomosis was contraindicated in each instance. The third case of peritonitis occurred following operation

TABLE I  
COLON RESECTIONS 1938 TO 1944

	Total Cases	Right Colon	Transverse Colon	Left Colon	Wound Infections	Eviscerations	Peritonitis	Average Hospital Stay (days)	Mortality	
									No.	Per Cent
Delayed anastomosis.	57	14	13	30	25	5	4	68.8	8	14.1
Primary anastomosis.	9	9	0	0	8	0	2	50.7	3	33.3

of 33.3 per cent. One death was the result of peritonitis; one was due to postoperative shock; a third fatality was due to cardiac failure and cerebral embolism; the remaining death occurred suddenly on the second postoperative day and was probably due either to coronary occlusion or a pulmonary embolus.

Primary anastomosis was performed in thirty-seven cases of large bowel resection

as a consequence of edema and obstruction of the operative stoma and resulting perforation of the cecum. This patient also died. Of the two cases of localized intra-abdominal abscess, one was due to perforation of the carcinoma and abscess formation preoperatively and one was the result of leakage at the line of anastomosis. Of the entire group of thirty-seven cases of resection with primary anastomosis, the latter

TABLE II  
COLON RESECTIONS 1945 TO 1947

	Total Cases	Right Colon	Transverse Colon	Left Colon	Wound Infections	Eviscerations	Peritonitis	Localized Abscess	Average Hospital Stay (days)	Mortality	
										No.	Per Cent
Delayed anastomosis.	12	1	0	11	1	0	1	1	43.8	4	33.3
Primary anastomosis.	37	9	4	24	2	0	3	2	22.8	4	10.8

for carcinoma during the 1945 to 1947 period. There were nine right colectomies, four transverse colectomies and twenty-four resections of the left colon. In this group there were two instances of wound infection, three cases of peritonitis and a localized intra-abdominal abscess occurred on two occasions. Two of the cases of peritonitis were due to preoperative perforation

case was the only instance in which there was evidence of leakage at the anastomatic suture line. In this case the abscess was drained and the patient recovered. The average hospital stay of this group of cases was 22.8 days. There were four deaths in this series, a mortality rate of 10.8 per cent. Three of the four fatalities were the result of peritonitis. As indicated above, in two

of these cases peritonitis was present prior to operation and primary anastomosis was probably ill advised. The fourth death was due to cardiac failure and pulmonary edema.

As can be seen by comparison of the figures in Tables I and II, in each of the anatomic groups of colon carcinoma we have used the procedure of resection with immediate anastomosis as opposed to exteriorization and delayed anastomosis with increasing frequency during the past few years. And this, despite the fact that in recent years our limits of resectability have been extended to the point where only if the bowel is completely frozen or the liver studded with metastases is a palliative operation performed.

Accumulated surgical knowledge of the past decade has been largely responsible for the changes which have made primary anastomosis in colon resections a relatively safe and accepted procedure. This newer surgical knowledge has been incorporated into the details of pre- and postoperative care and operative technic which are of such paramount importance in the ultimate surgical result. It has been on the basis of this newer knowledge that we, as well as others, have more or less standardized our procedure. In the preoperative preparation of the patient for colectomy attention is directed primarily to the correction of anemia, the correction of nutrition and the proper preparation of the large bowel. Transfusions are used liberally to bring the patient's hemoglobin to within normal limits. A high protein, low residue diet, parenteral amino acid solutions and vitamins are used routinely to replenish the nutritive loss that many of these patients have undergone. The preparation of the large bowel is begun by one or two doses of magnesium sulfate, and the bowel is kept clean with daily enemas or colonic irrigations. Sulfasuxidine or sulfathalidine—usually the latter—is given routinely for about five days before operation is contemplated. In acute, complete obstructions preliminary cecostomy or transverse colostomy may be necessary.

However, when obstruction is only partial, conservative methods are often adequate to relieve the obstruction and decompress the bowel. If small as well as large bowel distention is present, a Miller-Abbott or Cantor tube is used. Mineral oil is given by mouth, sulfasuxidine is used instead of sulfathalidine since it tends to produce a liquid stool. Colonic irrigations are given daily. Nutrition is supplied by parenteral means in the form of amigen and glucose solutions and the vitamins, B complex, C and K. It is only after the patient's cardiac, pulmonary and renal status have been completely evaluated and after he has received the fullest benefit of preoperative preparation that operation is undertaken.

During the past few years our colectomies have been performed under general, endotracheal anesthesia with cyclopropane and curare. The patient can be maintained under a relatively light plane of anesthesia with a high percentage of oxygen and relaxation of the desired degree can be obtained readily with small doses of curare given intravenously. Blood is given routinely during the operative procedure so that any drop in blood pressure is avoided. Either 500 cc. or 1,000 cc. of blood are given, depending on the length of the procedure and the condition of the patient. Our early primary anastomoses were done with the aseptic closed technic, using the Furniss clamp. However, during the past two years we have used open anastomosis almost exclusively with satisfactory results. Gross contamination will be minimal with a properly prepared bowel, with due care taken to wall off the remainder of the wound from the site of the open bowel and if gloves and wound drapes are changed after the anastomosis is completed. We believe that open anastomosis is more accurate and results in a smaller diaphragm within the lumen of the bowel. Our anastomosis is performed with two rows of interrupted fine silk sutures, an inner layer which passes through the entire bowel wall and an outer seromuscular layer. We have not used complementary colostomy or ileostomy in any of our resections. Since

1945 we have closed all our abdominal wounds with steel wire with very satisfactory results.

Postoperatively nutrition is maintained by the parenteral administration of amigen and vitamins until the patient is able to take an adequate amount of food orally. Nothing is given by mouth for about twenty-four hours after operation. Small amounts of fluids are then allowed orally. Food intake is started and increased as the patient's condition warrants. He is usually eating a fairly adequate diet by the fifth or sixth day. Repeated aspirations of the stomach with the Levine tube during the first few days are usually sufficient to prevent any significant degree of abdominal distention. With the aid of a glycerin suppository the patient will usually have a bowel movement by the fourth or fifth day. The patient is ambulated either in the evening of the day of operation or on the morning of the following day. Sulfathaladine is given routinely after operation. Patients are carefully observed for the possible development of phlebothrombosis. Heparin in Pitkin's menstruum, given subcutaneously, has been used for the treatment of this complication. There have been no fatalities from pulmonary embolism in any of the patients treated by this method. It has been our experience that with careful attention to detail and with the utilization of modern adjuvants which have greatly increased the safety of surgery, that even aged and debilitated patients will withstand extensive operative procedures surprisingly well.

In view of the experience presented we believe that at the present time in the properly selected case, primary anastomosis following colon resection offers the best chance for a favorable outcome. We reserve exteriorization for those patients in whom there is evidence at the time of operation of intestinal obstruction local bowel inflammation and infection or marked fixation of bowel. With immediate anastomosis the morbidity and hospital stay are significantly reduced. In addition, the risk and inconvenience of a second operation and a second anesthetic are avoided.

There is a good deal less discomfort to the patient. The incidence of postoperative ventral hernia is less. Often a more extensive and radical resection can be performed by utilizing primary anastomosis since the length of bowel necessary for exteriorization through the abdominal wall is not required. The benefits of immediate as opposed to delayed anastomosis are further reflected in the decreased strain on the patient's mental, physical and financial reserves.

#### SUMMARY

1. We have reported our experience with 115 colon resections for carcinoma, exclusive of carcinoma of the rectum, during the ten-year period from 1938 to 1947. During the seven-year period from 1938 to 1944 most of our resections were done by some form of exteriorization procedure, with temporary colostomy and delayed anastomosis. Since 1945 we have followed colon resection by primary anastomosis in every case unless there was a contraindication to such procedure.

2. The changing trends in surgery have resulted in an ever increasing number of advocates of primary anastomosis in colon resections. It has been the experience of most workers that primary anastomosis in the selected case is at least equally as safe as any form of exteriorization procedure. In our hands, as a matter of fact, the mortality from exteriorization operations was higher than those following closed resections.

3. Some of the more important details of pre- and postoperative care of the patient with carcinoma of the colon have been briefly outlined and we have discussed some of the features of our operative procedure.

4. Colon resections with immediate anastomosis result in reduced morbidity, decreased hospital stay and in increased comfort and well being of the patient.

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# TARDY ULNAR PALSY\*

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PANAS<sup>1</sup> in 1878 first described the syndrome that was later to be designated by Hunt<sup>2</sup> as tardy, late or delayed paralysis of the ulnar nerve.

Tardy ulnar palsy is a condition characterized by the insidious onset of paresis or paralysis of the ulnar nerve following months or years of minimal trauma to the nerve adjacent to the elbow. Although this condition is relatively rare, it must be recognized as an important complication of old injuries in this region. Surgical treatment should be instituted promptly after the diagnosis has been made since this is the only satisfactory form of therapy.

At the elbow the ulnar nerve lies directly upon the periosteum in a groove along the posterior aspect of the medial humeral condyle. In this area the nerve is covered only by fascia and skin and is therefore particularly vulnerable to trauma. Tardy ulnar palsy, however, is not the immediate result of an injury to the structures about the elbow: it is, instead, the cumulative effect of repeated minor traumas which finally produce a paralysis of the nerve many months or many years after an initial injury.

Tardy ulnar palsy is most frequently seen as a complication of improperly treated fractures of the lateral humeral condyle. The condylar fragment is displaced proximally and laterally, with a resulting cubitus valgus deformity. Since many of these fractures occur in childhood, the valgus deformity of the elbow usually continues to increase during the growth period. Because the ulnar nerve is forced to traverse a longer route across the elbow, it becomes overstretched when the elbow is flexed. Other conditions which may eventually produce tardy ulnar palsy include the slipping of the nerve over a

displaced medial condyle and olecranon, pinching of the nerve between the medial condyle and the olecranon, partial incorporation in callus formation following fracture, adhesions within the ulnar groove preventing the normal mobility of the nerve with movement of the elbow, hypertrophic arthritis, foreign bodies, exostoses, congenital anomalies, recurrent dislocation of the elbow and occupational trauma. Gay and Love<sup>3</sup> found an old fracture of the elbow to be the causative factor in 57 per cent of their cases and arthritis to be the cause in 20 per cent.

The nerve lesion usually associated with tardy ulnar palsy has been designated by Seddon<sup>4</sup> as "axonotmesis." This signifies that there has been damage to nerve fibers so severe that complete peripheral degeneration has resulted, while the sheath and more intimate supporting structures of the nerve have not been completely divided and the mass of nerve tissue remains in continuity. Typical of this type of nerve injury is the so-called "spindle pseudoneuroma" occurring at the point of greatest strain on the nerve. This swelling is the result of an initial rupture of the perineural sheath through which the neural fasciculus herniates under pressure. Whether or not recovery of function will be complete after neurolysis depends largely upon the extent of this herniation and upon the amount of endoneural hemorrhage. In the subsequent process of tissue repair regenerating neural bundles may become so ensnared by the scar tissue as to be non-functional. The pseudoneuroma, once begun, enlarges by the influx of fluid into the endoneural space.

In its course from arm to forearm the ulnar nerve lies in the medial paraolecranon groove and makes its exit from the elbow region by passing between the heads

\* From the Cleveland Clinic and the Frank E. Bunts Educational Institute.

of the flexor carpi ulnaris muscle. Usually there are two small motor branches to the flexor carpi ulnaris which arise from the nerve just proximal to the elbow joint. In the forearm the ulnar nerve supplies both the flexor carpi ulnaris and the portion of the flexor digitorum profundus which controls the little and ring fingers. In the hand the ulnar nerve supplies all of the intrinsic musculature except the opponens pollicis, flexor pollicis brevis, abductor pollicis brevis and the first and second lumbrical muscles. Sensory distribution of the ulnar nerve is limited to the medial aspect of the hand, including the entire little finger and the medial half of the ring finger.

In cases of tardy ulnar palsy the degree of nerve injury may vary from slight paresis to nearly complete paralysis. Patients with tardy ulnar palsy usually complain first of paresthesia or hypesthesia in the ulnar sensory distribution. This is followed by increasing weakness or awkwardness in the use of the intrinsic muscles of the hand and finally by paralysis of the muscles supplied by the ulnar nerve. Atrophy of the interossei and the hypothenar muscles may be the most striking feature of the condition. The majority of patients with tardy ulnar palsy demonstrate a tender enlargement of the ulnar nerve in the medial paraolecranon groove; Tinel's sign may be elicited over this enlargement.

Many cases of tardy ulnar palsy could be prevented by proper recognition and early adequate reduction of fractures involving the lateral humeral condyle. Open reduction of these fractures is frequently necessary. In the treatment of injuries to the elbow in children it is most important to compare roentgenograms of the injured elbow with those of the uninjured elbow. A minor displacement of one of the epiphyses about the elbow may thus be diagnosed and proper treatment instituted.

After a tardy ulnar palsy has developed, treatment is directed toward the nerve disability rather than toward the cubitus valgus, exostosis or other deformity which

may be present. The only treatment which has been found effective is surgical relocation of the ulnar nerve from the posterior aspect of the medial condyle to the antecubital fossa. After application of a pneumatic tourniquet, a curved longitudinal incision is made over the posteromedial aspect of the elbow, beginning about 2 inches above the medial epicondyle and proceeding distally in line with the course of the ulnar nerve for a distance of about 6 inches. The aponeurosis of the triceps tendon and the deep fascia are divided to expose the ulnar nerve over a distance of about 5 inches. The motor branches of the nerve, usually two in number, are isolated and, as the nerve is lifted out of its groove, these motor branches are carefully separated from the main trunk of the nerve to a point well above the elbow. This permits the surgeon to transfer the nerve anteriorly without placing undue tension upon these motor branches. In its new bed the nerve is carefully sutured in place between the deep and superficial fasciae, utilizing fascial loops in the region or sewing the two layers of fascia together to prevent backward displacement of the nerve. Bunnell<sup>5</sup> recommends that in muscular individuals it is probably better to re-route the nerve between the flexor profundus muscle and the flexor sublimus and pronator teres muscles by severing the epicondylar origins of the latter two muscles and reconnecting them after the nerve has been re-routed. This places the nerve in a muscular bed and minimizes the danger of further injury to the nerve from pressure upon it by outside objects.

If a psuedoneuroma is encountered in the ulnar nerve, a neurolysis is usually done. This is accomplished by making longitudinal incisions through the outer layers of the neuroma; these incisions are made at regular intervals by the use of a sharp razor blade. It is believed that such a neurolysis may hasten the regeneration of the paralyzed nerve.

Postoperatively the elbow is fixed at right angles using a snug but not con-

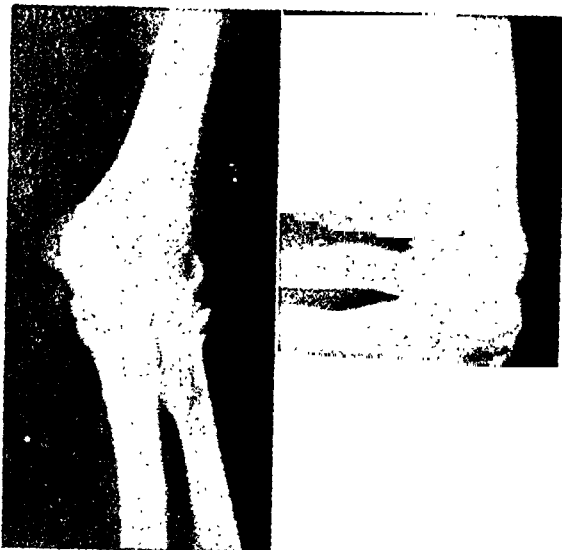


FIG. 1. Lateral and anteroposterior x-ray plates of right elbow showing extensive osteo-arthritis without evidence of old fracture.



FIG. 2. Case 1; severe cubitus valgus deformity of the left elbow.

stricting pressure bandage and a posterior molded plaster splint. After ten days the skin sutures may be removed and the arm placed in a sling. Rapid mobilization of the elbow joint may be encouraged, especially if the flexor sublimus and pronator teres muscles have not been detached.

The recovery of ulnar nerve function may extend over a period of twelve to fourteen months,<sup>6</sup> with nerve fibers growing at a rate of 3 mm. per day for the first one hundred days and 1 mm. per day thereafter.<sup>7</sup> Signs of nerve recovery follow a definite pattern: first, there is an arrest of further muscle atrophy or further sensory loss, then gradual disappearance of objective sensory loss and, finally, there is return of voluntary movement in the formerly paralyzed muscles.

#### COMMENT

A review was made of 154 cases with ulnar nerve lesions seen at the Cleveland Clinic from 1936 to 1948. In this group only nine cases were diagnosed as tardy ulnar palsy. We have obtained follow-up information in seven of these cases. The longest postoperative period is twelve years, the shortest, sixteen months. One patient considers himself entirely cured and six of the patients are improved.

Anterior transplantation of the ulnar nerve was carried out in seven cases. In one case this operation was advised but treatment was refused by the patient. In the other case, because of advanced age and poor general physical condition, conservative therapy was instituted. At the time of operation the ulnar nerve in the medial condylar groove exhibited a pseudoneuroma and fibrous adhesions in three cases, a pseudoneuroma alone in three cases and no demonstrable nerve lesion in one case. In each case the ulnar nerve was transplanted anteriorly between the superficial and deep fasciae. Neurolysis was carried out in four cases.

In seven cases there was a history of severe trauma to the elbow. Five cases had fractures of the lateral condyle, one had a fracture of both the lateral and medial condyles and one had a dislocation of the elbow without fracture, but with the subsequent development of severe osteoarthritis and multiple loose joint bodies. All of the fractures occurred in childhood. The period of time which elapsed between the original trauma and the onset of the ulnar



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FIG. 3. Case 1; preoperative atrophy of left hand musculature.

FIG. 4. Case 1; appearance of hand twelve years postoperatively showing complete regeneration of left hand musculature.



5

6

FIG. 5. Case 11; pronounced interosseus atrophy typical of tardy ulnar palsy.

FIG. 6. Anteroposterior x-ray plate of left elbow showing an old ununited fracture of the left humerus with valgus deformity of the elbow and secondary hypertrophic change.

nerve symptoms ranged from fifteen to forty-seven years, averaging 32.5 years.

In two of the cases there was no history of previous trauma to the elbow and both had extensive osteoarthritis. One of these patients (Fig 1) was operated upon and no apparent abnormality of the ulnar nerve was observed. Anterior transplantation of the ulnar nerve was performed which resulted in definite improvement in the patient's symptoms. Three years following operation he reported that there was still slight numbness in the ulnar distribution of his hand but to a lesser degree.

The most frequent symptoms in all cases were weakness of the muscles supplied by the ulnar nerve and numbness in the ulnar distribution. Six of the cases revealed definite atrophy of the interossei and hypothenar muscles.

The average time which had elapsed between the onset of ulnar nerve symptoms and the first examination at the Clinic was fourteen months. This fact illustrates the insidious onset of tardy ulnar palsy.

#### CASE REPORT

The following cases demonstrate the typical clinical course of tardy ulnar palsy:



CASE I. A forty year old white man was first seen at the Cleveland Clinic in November, 1936. He complained of atrophy of the interosseus muscles of the left hand, with numbness and intense weakness in his hand of two years' duration. He had also experienced a burning sensation in the ring and little fingers for the past ten months, with increasing sensitivity to cold. He was unable to carry on his work as an electrician. The past history revealed a fracture of the left elbow joint at the age of two years. Examination of the elbow showed an increase of the carrying angle to 30 degrees. (Fig. 2.) There was severe interosseus and hypothenar atrophy, with hypesthesia over the ulnar nerve distribution in the left hand. (Fig. 3.) Roentgenograms showed an old healed fracture of the lateral humeral condyle with lateral and proximal displacement. On November 21, 1936, an anterior transplantation of the left ulnar nerve was performed. At the time of operation a pseudoneuroma with many fibrous adhesions was identified in the ulnar groove. Improvement began seven months after operation with reduction of numbness as the first sign in recovery of the ulnar palsy. One year postoperatively the sensation in the left hand was normal but the interosseus atrophy and weakness persisted for at least another year. At the present time, twelve years after the operation, he has no atrophy, weakness or numbness of the hand. (Fig. 4.) The patient considers himself completely cured and is able to carry on his usual occupation.

CASE II. A fifty-one year old white man noticed weakness and numbness in the distribution of the ulnar nerve in his left hand for a period of nine months. His past history re-

vealed a fracture of the left elbow at the age of ten. Physical examination revealed moderately severe cubitus valgus deformity of the left elbow with the range of motion from 155 degrees extension to 45 degrees flexion. There was normal rotation in the forearm and slight crepitus at the elbow. The hand showed atrophy of the interosseus and hypothenar muscles, with sensory loss over the ulnar distribution. (Fig. 5.) X-ray examination of the left elbow revealed an old ununited fracture of the lateral condyle of the humerus with displacement proximally and laterally. (Fig. 6.) Anterior transplantation and neurolysis of the left ulnar nerve was performed on June 24, 1947. A large pseudoneuroma was found in the portion of the ulnar nerve lying within the paraolecranon groove. A follow-up examination sixteen months postoperatively revealed definite improvement of the sensory and motor function although there was still slight numbness in the ulnar distribution and moderate atrophy of the interosseus muscles.

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# GERIATRIC ANESTHESIA

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THE spectacular increase in life span of the past forty years has created new problems not only in social and economic fields but in many phases of medicine and surgery as well. The purpose of this paper is to bring into sharper focus the fundamental nature of these problems as they affect the anesthesiologist as well as a present day approach to their anesthetic management.

The anesthesiologist is concerned directly with the senescent changes seen in the cardiovascular, respiratory and excretory systems. It is these changes which are mainly responsible for the diminished ability of the aged to maintain homeostasis in the face of strain. For example, the efficiency of the respiratory system is adversely affected by tissue fibrosis and loss of elastic tissue. Thus emphysema, usually of the atrophic variety, is common among these patients. This condition, combined with an increased susceptibility to depressant drugs, results in an increased tendency to hypostasis, atelectasis and many of the other respiratory derangements complicating surgical intervention. In the bronchi loss of elastic tissue and mucosal atrophy results in a retardation of bronchial functions. Consequently, the elimination of secretions and foreign matter from the respiratory tract is sluggish and inefficient. A late, overall effect of pulmonary aging is a state of chronic hypoxia due to diminished ventilation, a reduction in the number of functioning alveoli and decreased permeability of the alveolar walls.<sup>1</sup>

Only an incomplete listing of the important consequences of cardiovascular aging as they affect the anesthesiologist is possible here. These include: (1) increased incidence of cardiac irregularities and vascular spasms; (2) diminution of arterial

elasticity and of blood supply to various organs, most significant in effect on function of heart, brain, kidney and liver; (3) hypertension; (4) decreased response or abnormal response to both vagal and sympathetic stimulation and (5) increased tendency to thrombosis and embolism associated with diminished plasma volume.

Certain pharmacologic deviations must also be kept in mind if a rational approach to the anesthetic treatment of the geriatric patient is to be attempted. The absorption of drugs, whether given by inhalation, rectum, mouth or subcutaneously, is generally slower than in younger individuals. Further, drugs which are eliminated via the respiratory tract or kidneys are lost more slowly. As one consequence of the reduced metabolic rate the destruction of drugs by oxidation or conjugation also proceeds more slowly. These factors naturally increase the possibility of toxic or of excessive cumulative action by drugs. Therefore, special caution must be exercised in the use of depressant drugs.

Many other changes accompany the aging process in various tissues and organs. While these may assume great importance in dealing with any individual patient, such detailed consideration is beyond the scope of this paper.

With these basic considerations in mind, the practical problem of the premedication for these patients may be discussed with better comprehension of the factors involved. Four basic reasons for premedication are to decrease the metabolic rate, allay anxiety, lessen secretions and diminish reflex activity.

Since age has already lowered the metabolic rate, psychic sedation remains as one of the major pre-anesthetic objectives. If the proper rapport is established between the patient and the anesthetist,

much can be accomplished toward mental preparation of the patient without recourse to drugs in dosages which may impair homeostatic mechanisms to a dangerous degree. This need for individual, sympathetic, consideration of every patient is so great that it is impossible to generalize about the dosage of drugs employed except to state that routine premedication, especially routine morphine dosage, must be shunned. The actual effects of morphine which provide the basis for this conclusion include its central depressant action on respiration, depression of the cough reflex, accentuation of bronchial spasm and a hypnotic effect which causes a general diminution of muscular tone.<sup>2</sup>

Atropine is commonly used for control of secretions and reflexes. Scopolamine, because of its central depressant effect which may cause an excited, uncooperative or stuporous patient, has been discarded for these patients by some anesthesiologists. Others continue to use this drug with good results, probably because of greater caution as to the dose they employ.

Atropine is frequently used with meperidine hydrochloride to produce a pre-anesthetic effect characterized by little or no respiratory depression, satisfactory sedation and excellent control of secretions.

Barbiturates in proper dose and time will result not only in an optimistic, well rested patient but frequently provide an excellent indication of the patient's susceptibility to sedative drugs. Barbiturates are also indicated when regional or local anesthetic procedures are contemplated. A small dose of one of the shorter acting barbiturates given two hours before the induction of anesthesia will enhance the sedative action of the opiate and exert a protective action against the toxic effects of the local anesthetic agent.<sup>3</sup> It should be remembered, however, that barbiturates like scopolamine may cause excitement and confusion.

Insufficient premedication frequently can be made adequate by an understanding, reassuring attitude on the part of the

anesthetist. If necessary, additional intravenous medication may be employed in judicious dosage. Oversedation, on the other hand, will make the induction of anesthesia more hazardous even in the hands of the most skillful and may necessitate the postponement of the procedure.

Mention should be made of some of the preoperative therapeutic medications which may affect the course of anesthesia beneficially. These include blood and other fluids, vitamins, anticoagulants, antibiotics and hormones.

Although partial plates and small removable dentures should be removed as part of the pre-anesthetic preparation, intentionally allowing elderly patients to retain their full plates will result in an improved psychic outlook by certain patients and will frequently simplify the induction and maintenance of inhalation anesthesia.

#### ANESTHETIC METHODS AND AGENTS

The selection of an anesthetic method should be based on an evaluation of the patient and his condition, especially his cardiovascular, pulmonary and renal status, the methods available, the anesthetist's abilities and the surgeon's needs.

*Local and Regional.* With this type of anesthesia many of the systemic effects of general anesthesia may be eliminated. Coincident with the improvement in administration of general anesthesia has come the realization that, for many individuals, local procedures may be more shocking than general anesthesia. On the other hand, certain operative procedures lend themselves extremely well to skillfully induced local anesthesia. Abdominal field blocks for enterostomy, colostomy and cystostomy, as well as the various extremity blocks for orthopedic procedures, are examples. Caudal block for rectal and perineal procedures has proven extremely useful. Peridural block anesthesia has been more popular in South American and European clinics than in this country, possibly because of the technics involved.

The demonstration by Curbello in Cuba of the feasibility and wide applicability of continuous segmental epidural block may lead to more extensive employment of this method in this country both for surgery and as a therapeutic measure.<sup>4</sup>

The axiom that as far as the patient is concerned no really good anesthesia can be purely local applies with equal or greater force to the geriatric patient. Supplementation with large amounts of sympathetic attention and minute quantities of sodium pentothal and oxygen can convert an ordeal into a comparatively pleasant experience.

*Spinal Anesthesia.* For many procedures which can be performed with anesthesia levels below D10 spinal anesthesia may be the one of choice. The tendency today is toward the use of smaller quantities of the anesthetic agents, especially in elderly patients. With skill and care surprisingly small doses are found to be entirely adequate. Unilateral anesthesia, permitting further reduction in dosage and systemic effect, is frequently possible. Of course, the absolute and relative contraindications such as central nervous system disease, severe anemia, severe hypertension, shock, marked blood pressure fall following premedication and an uncooperative attitude by the patient must be considered in each case. Supportive therapy includes ephedrine at the time of the spinal tap, intravenous fluids and oxygen, both started immediately following induction. The use of continuous spinal anesthesia for lengthy operations adds to the safety of the method.

*Refrigeration Anesthesia.* For elderly, debilitated patients who are to undergo amputation of an extremity, refrigeration has been reported to be a method of choice. Many patients actually seem to improve after the induction of anesthesia. The disadvantages are the slow and cumbersome nature of the method.

*Intravenous Anesthesia.* Sodium pentothal in a 0.1 or 0.2 per cent solution is a suggested drug for many minor procedures such as manipulations and examinations.

The smooth, pleasant, induction and the absence of frightening apparatus are important advantages. When given as a supplement to regional and local anesthesia, it is of especial value in deaf and dumb, senile and other apprehensive patients whose cooperation may be difficult to obtain.<sup>5</sup> In conjunction with curare and a 50:50 mixture of nitrous oxide and oxygen the method lends itself to almost any procedure. Because of the generally diminished autonomic reactivity of the aged, contraindications are fewer than with young, vigorous patients.

*Basal Anesthesia.* Basal anesthesia is extremely satisfactory from the psychic standpoint. Ether in oil, avertin and sodium pentothal have been employed rectally to produce basal anesthesia. As with other drugs, variability and toxicity tend to be greater in the aged. Generally speaking, therefore, dosage should be much reduced. The unfortunate experiences of the past in connection with basal anesthesia have almost always resulted from overdosage, either inadvertently due to lack of familiarity with the method, or deliberately, in an attempt to produce surgical anesthesia by this means alone.

Romig and Donahue have reported on their successful use of avertin for basal anesthesia in the aged.<sup>6</sup> Rectal sodium pentothal also has been employed with success for basal analgesia, but the variability of action appears to be greater than with avertin and the duration of action appreciably shorter. Gwathmey was one of the original exponents of rectal ether oil anesthesia.<sup>7</sup> However, the same factors which tend to make inhalation ether disadvantageous in the aged have made this method less popular than basal avertin. Similarly, basal anesthesia with intravenous ether has been employed without any real advantages and some serious disadvantages making themselves apparent.

*Inhalation Anesthesia.* At the present time inhalation anesthesia remains the mainstay in the clinical anesthetist's approach to anesthetic choice. The different

agents available should be evaluated from the standpoint of the altered physiology of the aged patient. Nitrous oxide, for example, because of its low potency which frequently tempts the administrator to employ it with diminished oxygen tensions, is usually contraindicated as a sole agent. The potency of ethylene, on the other hand, while considerably less than that of cyclopropane, is sufficient to permit many procedures to be performed with adequate oxygenation and relaxation. Requirements in these patients for a potent agent are so much less that ethylene naturally makes an ideal agent for them. Because of its potency cyclopropane permits high oxygen concentrations and has wide applicability. Due to its comparative pleasantness for induction and its favorable effect on hemodynamics as compared with ether or pentothal,<sup>8</sup> it has few contraindications in the hands of those experienced with it. By adding small quantities of ether to the mixture the stability and safety of the anesthesia may be increased, and by giving procaine in an intravenous infusion during the operative procedure it has been successfully employed even when relative cardiac contraindications existed.<sup>9</sup>

Ether finds its major use in geriatric anesthesia as a supplementing agent, using small amounts only, rather than as a primary anesthetic agent. Its unfavorable effect on hemodynamics has been mentioned.

*Curare.* The role of curare in increasing the safety of anesthesia by providing adequate relaxation for the surgeon while the patient is in light anesthesia has been firmly established. Its dangers and the fact that its use will not compensate for poorly given anesthesia have been equally well established. Clinical and experimental work now in progress seems to indicate that in addition to its effect on the myoneural junction, curare in large doses has a beneficial effect on certain types of reflex activity. Thus, obtundation of certain reflexes quite similar to that seen under deep general anesthesia may be possible without

any general anesthesia at all. This may explain the observation that very light anesthesia, such as that produced with nitrous oxide and "heavy" curarization, is, contrary to expectation, accompanied by decreased shock.

*Supportive Therapy.* Because of their comparatively diminished ability to compensate for blood loss, positional disadvantages and operative trauma, supportive therapy during anesthesia must be anticipatory whenever possible. There is no good rationale for the postoperative transfusion. Blood loss should be compensated for almost "before" it occurs. If clinical evidence of excessive blood loss is awaited, irreversible shock may set in.

Plasma and saline constitute poor substitutes for blood. The same is true for the analeptics, and their use in a patient whose compensatory mechanisms are already strained to the utmost may be followed by total collapse.

The special supportive measures—ephedrine, oxygen and fluids—required under spinal anesthesia have been previously mentioned. Here, too, the aim is the *prevention* of drastic changes in the status of the patient. Such changes, if allowed to occur, may do irreversible damage to the brain, heart and kidneys.

No matter what type of anesthesia is employed, the diminished vital capacity of the elderly patient demands that special attention be paid to positioning both during and after operation. The Trendelenburg, lithotomy and kidney positions are the most detrimental for the patient in this respect.

*Post-anesthetic Care.* An important aim of postoperative care is the prevention of circulatory and respiratory complications. The role of the anticoagulants, of paravertebral sympathetic block and of prophylactic venous ligation has been adequately discussed by others.<sup>10,11</sup> An intelligently carried out regimen involving frequent moving about and early ambulation of the patient will greatly diminish the incidence of vascular accidents. Such a regimen, in

combination with scrupulous attention to the hygiene of the respiratory tract, will do much to prevent respiratory complications during the postoperative period.

Too early or excessive postoperative sedation is hazardous. About 30 per cent of patients require no analgesic administration in the postoperative period. Intercostal blocks following abdominal surgery, making use of intracaine in oil or similar preparations, are valuable for increasing the comfort of the patient and decreasing the need for sedation.<sup>12</sup> Demerol and codeine are frequently entirely adequate analgesics. When morphine is necessary for control of pain, it may be given with prostigmin to avoid the adverse effects of morphine given alone on the gastrointestinal tract.

Oxygen therapy is frequently indicated for these patients but any tendency to an indiscriminate or routine use should be avoided. Similarly, postoperative blood and fluid therapy should be administered on the basis of laboratory determinations as well as clinical impression.

Conscientious, sympathetic nursing care exerts a beneficial effect, not only by carrying out the prophylactic maneuvers already alluded to but by actually permitting a reduction of depressant medication to the necessary minimum. The value of a well run recovery ward in facilitating this type of care cannot be overestimated.

#### SUMMARY AND CONCLUSION

Some of the factors involved in the selection and administration of anesthesia to the geriatric patient have been discussed. The need for individualization has been

emphasized. Some aspects of pre- and postoperative care have been considered.

The principles of good anesthesia remain the same whether the patient is young or old. While cautious, exacting application of these established principles constitutes the essence of good anesthesia, good geriatric anesthesia requires even greater devotion to minute details.

We are greatly indebted to Drs. Morris K. Smith, Harold F. Bishop and Leo J. Fitzpatrick for their many invaluable suggestions.

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# INTRADIPLOIC EPIDERMOID TUMORS (CHOLESTEATOMA OF THE SKULL)\*

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**E**PIDERMoids, cholesteatomas, pearly tumors, or Cruveilhier's<sup>1</sup> *tumeurs perlées* are rare neoplasms of ectodermal origin. Remak<sup>2</sup> in 1854 advanced the thesis that these tumors are embryonic rests resulting from an incomplete separation of the neural from the surface ectoderm. They may occur within the skull or may arise within the diploe, causing erosion of the tables of the skull and pressure upon the underlying brain. They may arise within the ear and break through into the intracranial cavity, or may arise in or upon the brain itself.

Although true epidermoids may occur in connection with the internal ear, most of the masses referred to as cholesteatomas are in reality infectious débris consisting of ingrowing squamous epithelium, secondary to chronic infections in the ear and not true neoplasms. Epidermoids have been loosely called cholesteatomas and much discussion has arisen as to the propriety in the use of the term "cholesteatoma," since it is descriptive only of the chemical by-product of the tumor, cholesterol, not invariably present. Many years ago epidermoids were distinguished from dermoids on the basis of their embryology. This belief was supported by evidence that dermoids were the result of misplaced ectodermal cells, occurring from the third to the fifth week of fetal life; while epidermoids represent disturbances to the anlage after the neural groove has been closed, occurring after the fifth fetal week and resulting in the growths found in the meninges, diploe and superficial layers of the calvaria.

According to Pancoast<sup>3</sup> et al., true in-

tradiploic epidermoids are very rare but occasionally give rise to neurologic symptoms. Since 1922, when Cushing<sup>4</sup> reported a case of his own, some forty-one cases have been recorded in the literature and the surgical treatment of this condition has been placed on a firm basis. The clinical and x-ray picture which is caused by this tumor is typical and scarcely to be confused with any other condition. The examination usually presents a swelling on the surface of the skull which may have been present for some years. Ordinarily there is an associated palpable defect in the normal contour of the skull; such defects are generally surrounded by a bony ridge as the edges of the lesion are frequently surrounded by a mass which is soft and fluctuant. If the inner table of the skull has been eroded, transmitted pulsation of the tumor mass may be elicited. X-ray examination reveals a defect in the bones of the skull which may or may not be regular. The margins of the defect may be scalloped or smooth. The defect itself is caused by a tumor which arises within the diploe, spreading and eroding the inner and outer tables of the skull. At operation an encapsulated cyst is found presenting a whitish caseous mass or a series of whitish rings having the appearance of mother-of-pearl. The capsule is extremely thin and friable and is separated from its bony crater with difficulty. Since the wall of the cyst is composed of stratified squamous epithelium this must be completely removed in order to prevent recurrence; mere evacuation of the cyst is not sufficient.

Mahoney<sup>5</sup> in 1936 discovered only twenty-three diploic epidermoids in a

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series of 142 cases that he could find in the literature to which he added five cases collected in Foerster's Clinic, in Breslau. Mueller<sup>6</sup> in 1936 was the first to describe an intradiploic epidermoid and, aside from the three cases described by Bucy,<sup>7</sup> two by Rowbotham,<sup>8</sup> four by King<sup>9</sup> and ten recently described by Rand and Reeves,<sup>10</sup> only forty-one cases of epidermoids arising between the two tables of the skull have been culled from the literature to date.

This report is concerned with two cases of epidermoids of the calvarium in one of which there has been a highly suggestive history of preceding head injury.

#### CASE REPORTS

**CASE I.** This patient had a swelling in the right frontal region since the age of seven years following a head injury. There was a slow increase in size until the age of fourteen years associated with constant headaches and unsightly cosmetic deformity of the forehead. Operation consisted of removal of epidermoid of skull followed by immediate recovery. There was a recurrence three years later. Re-operation was carried out with removal including the pericranium and complete recovery followed.

S. N., a fourteen year old Junior High School student, referred by Dr. M. H. Rabwin, was admitted to the Queen of Angels Hospital, Los Angeles, July 12, 1944, because of swelling in the right side of the forehead. When she was seven years old, she bumped heads with another child, receiving a laceration in the right frontal region. She said she remembered this and that she was taken to the Receiving Hospital where six stitches were used to close the cut in her forehead. About six months later a bump began to form at the site of the scar. This continued and gradually became larger until it finally reached the size of a walnut. There had been moderate headaches present during the past seven years. However, the swelling in the right frontal region did not become painful.

Examination revealed a perfectly normal appearing girl in good general physical condition. In the right frontal region about midway between the eyebrow and the hair line was a swelling which was quite symmetrical and measured approximately 3 by 3 cm. in diameter. It was elevated about 1.5 cm. above the surrounding scalp. A fine linear scar ran

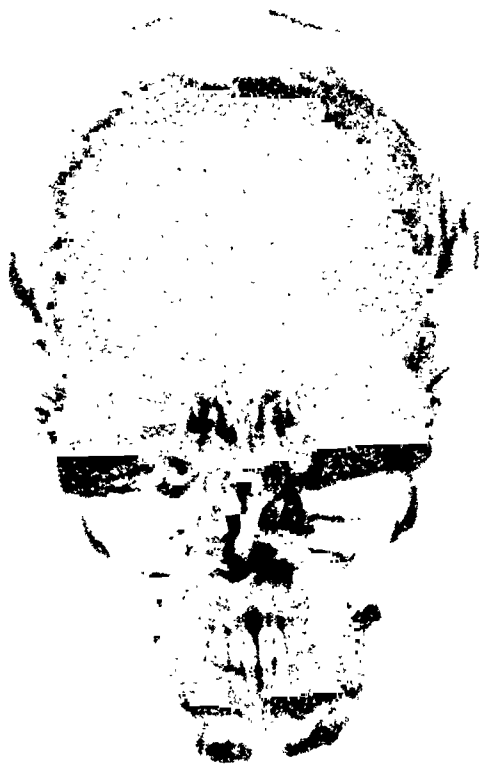


FIG. 1. Case 1; roentgenogram of skull, anteroposterior view showing circumscribed bony defect in the right frontal region characteristic of epidermoid tumor.

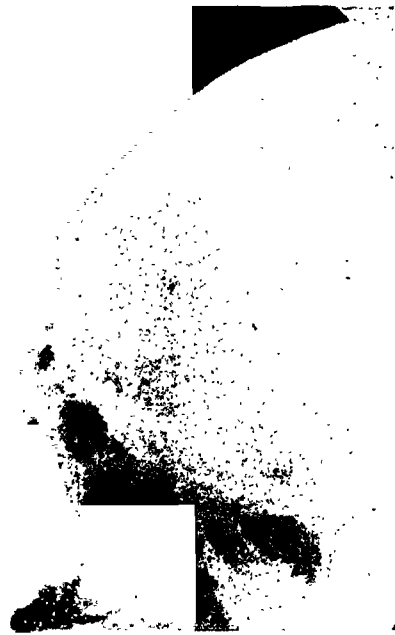
transversely across this elevation. From the dome of this elevation one received the impression of an indentation, with a sense of fluctuation. The edges were quite firm and crater-like. There were no signs of inflammation and no definite localized tenderness. There were no neurologic signs noted. The deep reflexes were quite sluggish but about equal. There were no abnormal reflexes. X-rays of the skull (Figs. 1, 2 and 3) showed a perfectly circumscribed bony defect in the right frontal region and outside of the right frontal sinus. It measured approximately 2 by 3 cm. in diameter. The margins were clear cut and appeared to have been caused by a pathologic process of a benign nature. In a tangential view the outer surface of the structure was elevated above the normal surrounding bone.

At operation on July 22, 1944, a semi-circular incision was made in the right frontal region behind the hair line, and upon reflecting the scalp flap downward a soft tumor mass was uncovered in the right frontal area and above the eyebrow, which appeared to be well encapsulated and was entirely beneath the peri-





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FIG. 2. Case 1; roentgenogram, lateral view, showing clear-cut, smooth margins of epidermoid tumor.

FIG. 3. Case 1; roentgenogram, tangential view, indicating the outer surface of the epidermoid to be elevated above the normal surrounding bone.

cranium. The tumor mass had its bed between both tables of the skull bone. The capsule of this tumor mass was carefully reflected away from the bony walls of the frontal bone and the entire contents were removed *in toto*. The size of this tumor mass was that of a walnut and its consistency was that of brick cheese. The bony bed of the neoplasm was inspected and found to be composed of an inner table of the skull, which was intact, the diploe and the eroded outer table. The cyst lining of this bony bed was carefully removed with a curette, the edges of the outer table were smoothed down with a chisel and the opening through the outer table was closed by suturing together the pericranium. The scalp flap was then returned to its normal position and the wound was closed in layers with interrupted black silk. The patient made a complete recovery and was discharged from the hospital at the end of two weeks.

Microscopic examination of the specimen revealed abundant non-descript keratin-like material arranged in layers. The color of this material was of a shiny, glistening white. Also seen was a thin fibrous transparent membrane representing a cyst wall. Microscopic examination (Fig. 4) of the cyst wall revealed on the lining aspect a thin layer of well formed stratified squamous epithelium, the basement mem-

brane of which was intact. Beneath this epithelial layer was a dense, fibrous connecting tissue. There were no glandular elements. The gross appearance of the contents of the cyst, together with the absence of glandular elements in the cyst wall, indicated that the cyst contained the accumulation of years of desquamated epithelium.

*Comment.* In this case there was the unusual history of a head injury which occurred seven years before the patient's admission to the hospital. The tumor was located directly beneath the site of the injury in the right frontal region and was associated with the typical defect in the skull. It was thought that perhaps some epithelial cells were driven down into the bony tissues at the time of this accident, thus giving rise to an epidermoid tumor. This patient returned to her classes in school and apparently did very well for several years. During the summer of 1947 she again noticed some swelling beneath the operative site in the right frontal region which felt soft and movable and evidently was a slow-growing recurrence of the original tumor mass. X-ray examina-

tions of the skull were made which again showed a circumscribed bony defect in the right frontal region entirely similar to the pictures made some three years previously. Physical examination at this time revealed no neurologic signs. The swelling in the right forehead felt fluctuant with firm edges and was elevated approximately 1 cm. above the surrounding scalp. The diagnosis of a recurrent epidermoid tumor of the skull was made.

On February 25, 1948, utilizing the original incision behind the hair line in the right frontal region, the scalp flap was turned down, uncovering the recurrent epidermoid tumor approximately the size of a small walnut in the right frontal bone. The pericranium about the tumor mass was incised and the underlying tumor was removed from its bed in the cranial vault. The outer table of the skull was found to be eroded and the base of the tumor was resting in the diploe. The bony bed was carefully curetted so that no fragments of the cyst wall were left behind. In closing this wound the evident mistake made some four years ago was not repeated when the pericranium had been closed over the bony defect in the skull. At this session the pericranium and the tumor mass were removed together precluding any further growth. The scalp flap was returned to its correct position and closed with multiple black silk sutures. The patient made an uneventful recovery and was discharged from the hospital five days later. To date there has been no sign of any further trouble.

**CASE II.** This patient complained of swelling in the right parietal region during the past seven years associated with severe headaches. There was an increase in size of the tumor mass to that of an orange. Frequent nausea occurred during the past year. The bony defect showed crater formation. The operation consisted of removal of the epidermoid tumor and the patient recovered.

N. S., a twenty-seven year old seamstress, referred by Dr. Walter Holleran, was admitted to the Queen of Angles Hospital on January 29, 1947, because of headaches and swelling of the scalp in the right parietal region. About seven years previously the patient had noticed a protuberance in the right side of the head about the size of an olive, which grew slowly until it reached its present size of a small

October, 1949



FIG. 4. Case 1; photomicrograph of lining membrane of epidermoid tumor showing layer of stratified squamous epithelium on which the growth of the tumor depends.

orange. At first it was very hard but later became soft and doughy. The patient never attached any importance to the tumor and thought that the headaches were due to some ailment of her eyes, so she went to an optometrist to have glasses fitted which did not relieve the condition. About one month before her admission to the hospital the patient had frequent periods of nausea and lost her appetite completely. There were no other complaints. She had the usual diseases of childhood. At the age of fifteen years she had two convulsive seizures which did not recur. She had an attack of malaria eight years previous to her hospital admission. There was no history of any accident or head injuries.

Examination revealed a pale appearing, twenty-seven year old girl in good general physical condition. In the right parietal region was a swelling the size of a tangerine which was quite fluctuant and soft and which measured approximately 5 cm. in its greatest diameter. There were no signs of inflammation and no definite localized tenderness. There were no objective neurologic signs noted.

X-ray examination (Figs. 5 and 6) revealed a sharply circumscribed defect in the right parietal bone. There was marked condensation of the margins of this defect. Overlying it was a shadow of the tumor mass. Tangential views

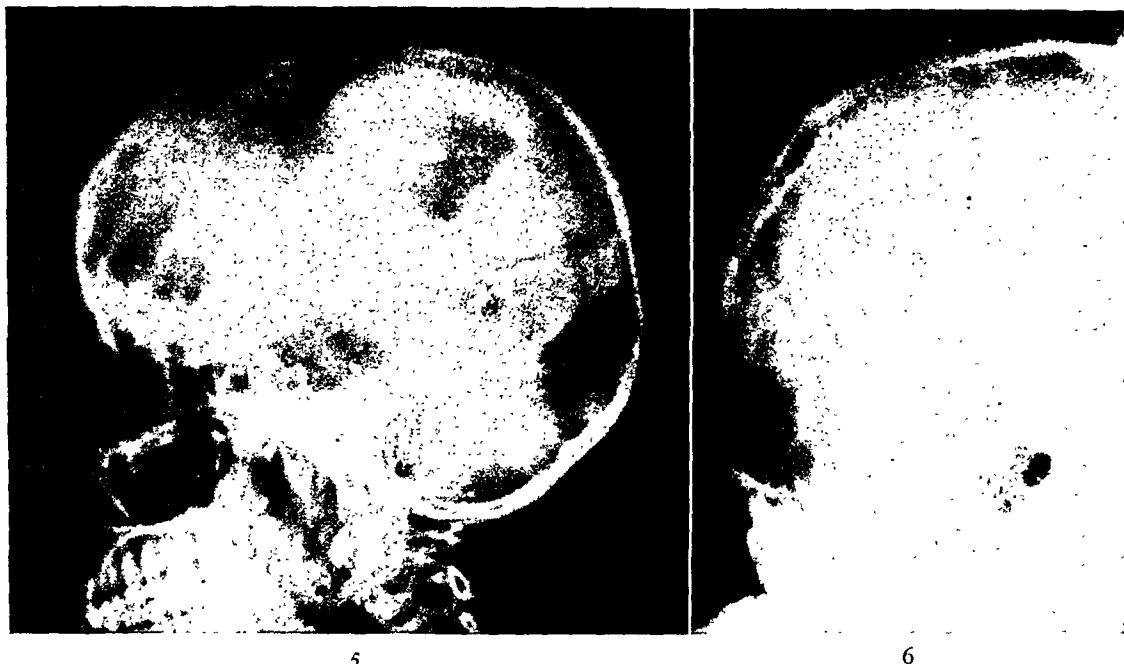


FIG. 5. Case 11; roentgenogram, lateral view, showing cholesteatoma, epidermoid of the cranial vault, with circumscribed defect in the right parietal bone. Overlying this defect is shadow of tumor mass.

FIG. 6. Case 11; roentgenogram, tangential view, showing destruction of the outer table of the parietal bone and depression and erosion of the inner table.

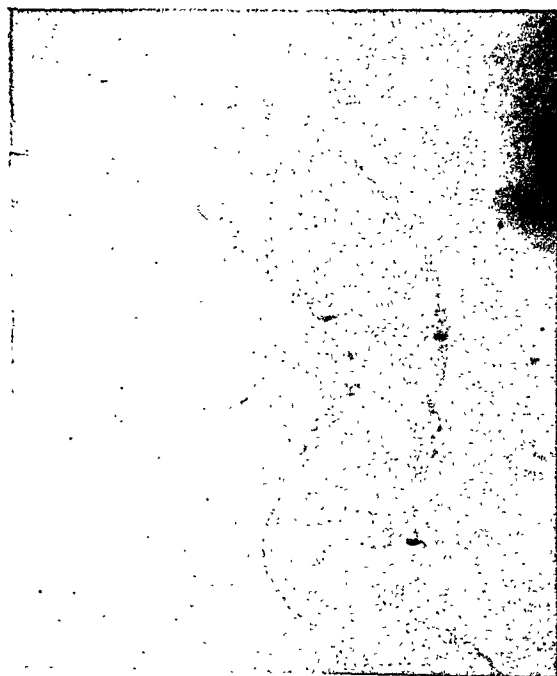


FIG. 7. Case 11; photomicrograph of epidermoid tumor with intact basement membrane of stratified squamous epithelium. There is a large amount of desquamated epithelium present which accumulated over a number of years.

demonstrated the destruction of the outer table of the parietal bone and depression of the inner table by expansion. The findings were consistent with a new growth involving the parietal bone and probably represented a cholesteatoma.

On January 21, 1947, a semi-circular flap of the scalp in the right parietal area was made, encircling the tumor mass for a distance of approximately two-thirds around its circumference. Upon reflection of this scalp flap a soft tumor mass was uncovered which seemed to have its origin in the ballooned-out diploe of the right parietal bone. An attempt was made carefully to dissect out and encircle this tumor mass without injuring it. However, at one point the capsule was so thin and friable that it broke open, allowing much of the cheesy, yellowish-white contents to escape. This was followed by a meticulous dissection of the entire capsule which seemed to fill a crater within the right parietal bone, easily 4 by 4 cm. in its greatest diameter. At the base of the crater an area of erosion down to the dura was discovered, exposing this membrane for at least  $1\frac{1}{2}$  cm. The bony defect was carefully curetted to remove every piece of capsule lining and therefore prevent any recurrence. The scalp flap was then closed with multiple interrupted black silk

sutures and the patient was returned to bed in good condition.

She made an uneventful recovery and was discharged from the hospital at the end of ten days.

The tumor specimen consisted of a collapsed cystic mass approximately 4 cm. in diameter. The wall was thin and fibrous. The lining surface was smooth and was covered with some adherent glandular gray sebaceous material representing the contents of the cyst.

Microscopic examination (Fig. 7) of the cyst wall showed on the lining surface a thin layer of essentially normal, stratified squamous epithelium the basement membrane of which was intact. The rest of the cyst wall was made up of a dense fibrous, partly hyalinized connective tissue. No dermal glands or hair follicles were seen in the section. On the outer aspect there was some fatty tissue and a small amount of striated muscle.

*Diagnosis:* epidermoid cyst.

*Comment.* This case represented a typical history of a tumor of long duration, with a clear cut defect of the skull recognized in the x-ray studies. Of interest, also, was the erosive action of the tumor causing a defect in the inner table of the skull exposing the dura. It is this type of case which might easily give rise to convulsive seizures, particularly when located in the parietal region, and which calls for diligent search of the bony crater and the surface of the exposed dura for any bits of lining which could give rise to recurrence.

#### SUMMARY

1. Two epidermoid tumors arising in the diploe of the frontal and parietal bones of the skull are described.

2. In Case 1 the tumor appeared to follow closely a head injury, an etiologic factor which heretofore has never been given serious consideration.

3. In both cases the patients complained of constant headaches and there was marked cosmetic deformity.

4. The roentgenographic findings in these lesions are extremely characteristic and

may be recognized preoperatively in the majority of instances.

5. The term "cholesteatoma" is confusing and should be avoided. The classification, primary cranial and intracranial epidermoids, as suggested by Monroe and Wegner,<sup>11</sup> indicates the true type, origin and location of these tumors.

6. Although these tumors are benign, the covering membrane of epithelium is active, and in order to prevent recurrence this lining membrane must be entirely removed at operation. One patient reported by Rand and Reeves<sup>10</sup> underwent operation four times before final removal and recovery took place.

7. Whenever the inner table of the skull has been found to be eroded, a careful search for an intracranial extension should be made.

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# SURVEY OF COMMON DUCT STONES IN CLINICAL AND NECROPSY CASES\*

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THIS study is based upon all cases of common duct stone admitted to the hospital for a period of twelve years, together with a review of all such cases found at postmortem examination at which time no such clinical diagnosis was made.

This review emphasizes the ease of recognition and the serious implications of common duct stones. It brings into relief the severe complications and mortality associated with conservative therapy. It emphasizes the necessity of exploring the common duct more frequently when removing a gallbladder, if the gallbladder is thick and contracted or if it contains black and tenacious bile; if there is jaundice; if the common duct is dilated and obviously if a stone can be palpated within. It shows the frequent need of aspirating the common duct in the absence of other indications, and then of exploring it if the bile is cloudy or contains flocculi because of the frequent presence of stones or chronic infection in the presence of such bile. It shows the real improvement following common duct drainage although no stone may be present.

The indications for exploring and draining the common duct, as emphasized by various authorities,<sup>1-8</sup> may be summarized as follows: (1) jaundice; (2) pain; (3) palpable stones in common or hepatic ducts; (4) dilated or thickened common duct; (5) chills and fever; (6) thickening of head of pancreas; (7) contracted gallbladder; (8) multiple small calculi or sand in gallbladder when cystic duct is large; (9) recurrent symptoms after cholecystectomy; (10) calculi removed from stool; (11) sediment in aspirated common duct bile.

In our series there were fifty-nine cases of common duct stones admitted to the hospital with this as a primary diagnosis, or patients who developed this complication while hospitalized. They show the frequency of pain, indigestion, acholic stools, jaundice, dark urine, chills and fever. The number of cases that presented signs and symptoms of common duct stones shortly after cholecystectomy is noteworthy.

In this survey the youngest patient was twenty-nine years old, the oldest sixty-nine. The chart shows the distribution of the cases by decades. There were forty-five females (74 per cent) and fourteen males (26 per cent).

Jaundice was the most common symptom appearing in forty-five (76 per cent) cases. Right upper quadrant pain was next, occurring in thirty-seven (63 per cent) cases. The associated symptoms in order of descending frequency were: (1) pain radiating to right scapular region or shoulder (twenty cases); (2) epigastric pain (nineteen cases); (3) vomiting (seventeen cases); (4) very dark urine (sixteen cases); (5) acholic stools (fourteen cases); (6) nausea (fourteen cases); (7) belching, bloated feeling (twelve cases); (8) pruritus (ten cases); (9) fever (eight cases); (10) chills (five cases). The associated physical findings in order of descending frequency were: (1) right upper quadrant tenderness (twenty-one cases); (2) enlarged liver (fourteen cases); (3) fever (eight cases).

The common laboratory findings were: (1) icteric index above normal (twenty-seven cases); (2) cholesterol above normal (nineteen cases); (3) cholesterol ester ratio less than 40 per cent (ten cases). Since

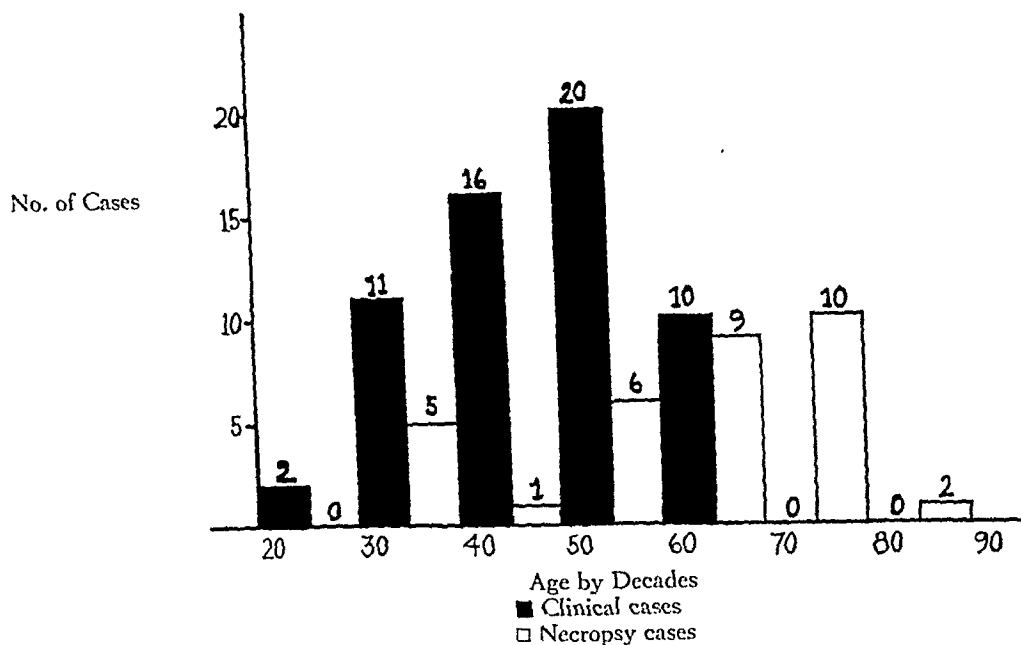
\* From the Departments of Surgery and Pathology, Queens General Hospital, Jamaica, L. I.

many of these cases go back several years, the laboratory data of other liver function tests such as Van den Bergh reaction and cephalin flocculation tests were insufficient to include them in this report.

It is interesting to note that seventeen (29 per cent) of the aforementioned

physical findings were suggestive of common duct stones. There is no operative proof that the diagnosis was correct.

Twelve patients were so diagnosed on admission or while hospitalized but signed out against advice before operative intervention or spontaneous subsidence.



patients had had a previous cholecystectomy and of these four had been operated within a period of two to three months prior to this admission. Six patients had had a previous cholecystostomy, making a total of twenty-three patients (39 per cent) requiring reoperation.

Twenty-five of the fifty-nine patients underwent a common duct exploration. Common duct stone was found in all but two. All patients responded well to the removal of the stones and T-tube drainage of the common duct except one in whom the technical difficulties of exposing the common duct were insurmountable and the patient succumbed shortly postoperatively. Postmortem examination showed a common duct stone with ascending cholangitis.

Twenty-two patients were not operated upon and according to the record the condition subsided spontaneously. This group is included because the history and

A review of the material from the Department of Pathology brought to light thirty-three cases of common duct stones. Of these fifteen had been operated upon and eighteen had not. The distribution of the cases according to age is shown on Figure 1. There were thirty-two white and one colored patient. Of these eleven were male and twenty-two female. Fifteen of these patients gave a history of abdominal pain; fourteen a history of jaundice; fourteen a history of chills and fever. Six had no biliary symptoms or signs.

The following is a list of the causes of death of the patients not operated upon in most of whom the common duct stones were incidental findings at the postmortem table:

1. Stones in the common duct associated with chronic cholecystitis in a case of bronchopneumonia
2. Stones in the common duct associated with chronic cholecystitis and cholelithiasis

in a case of osteogenic sarcoma of humerus with metastases

3. Common duct stones and chronic cholecystitis in a case of sickle cell anemia with subarachnoid hemorrhage

4. Chronic cholecystitis, cholelithiasis, choledocholithiasis with dilatation, chronic cholangiolitis in a case of adenocarcinoma of rectum and congestive heart failure

5. Chronic cholecystitis and choledocholithiasis in a case of coronary thrombosis with extensive myocardial infarction

6. Chronic cholecystitis, cholelithiasis and choledocholithiasis in a case of toxic hepatitis

7. Choledocholithiasis in a case of carcinoma of the head of the pancreas

8. Choledocholithiasis in a case of cholangitis due to stones in the biliary tree with recent coronary occlusion

9. Chronic cholecystitis, cholelithiasis, impacted stone in cystic duct with hydrops of gallbladder; impacted stone in common duct in a case of old and recent coronary occlusion

10. Choledocholithiasis in a case of ruptured gallbladder with regional abscess

11. Chronic cholecystitis and cholelithiasis; calculus in the common duct in a case of lobar pneumonia and cirrhosis of the liver

12. Stones in the common duct in a case of acute pancreatitis

13. Stone in the common bile duct in a case of cholangitis with severe biliary cirrhosis

14. Common duct obstruction by calculus in a case of cholemia

15. Chronic cholecystitis, cholelithiasis, choledocholithiasis in a case of acute endocarditis with multiple embolization

16. Cholemia due to obstruction by stone in the common duct in a case of papillary carcinoma of the gallbladder

17. Cholemia due to stone in common duct in a case of incarcerated ventral and inguinal hernia

18. Subphrenic abscess, cholecystitis, cholelithiasis, choledocholithiasis in a case of coronary sclerosis and nephrosclerosis

3. Massive intraperitoneal hemorrhage following cholecystectomy

4. Generalized peritonitis following cholecystectomy

5. Duodenal fistula with regional abscess following choledochostomy for impacted calculus

6. Coronary thrombosis with extensive myocardial infarction following cholecystojejunostomy

7. Acute pancreatitis with coronary insufficiency after cholecystectomy

8. Carcinoma of head of pancreas with widespread metastases; status post-cholecystojejunostomy

9. Generalized peritonitis with perforated diverticulum; post-cholecystoduodenostomy

10. Localized peritonitis with subphrenic abscess and hemoperitoneum following cholecystostomy and choledochostomy

11. Subdiaphragmatic and abdominal wall abscess with choledochoduodenal fistula

12. Common duct obstruction by stone, post-cholecystostomy

13. Sepsis in a patient with erysipelas of breast on whom a cholecystectomy was performed; calculus in common duct

14. Myocardial insufficiency and portal thrombosis; status after cholecystostomy

15. Abscess of gallbladder with extension to liver; peritonitis; status after cholecystostomy

Six of the above fifteen patients had only cholecystectomies or cholecystostomies performed although the postmortem examination showed common duct stones. Jaundice associated with pain and chills and fever are the common symptoms differentiating common duct stone from other conditions, such as carcinoma of head of the pancreas. An analysis of the thirty-three postmortem cases shows the following causal relationship of common duct stones to death:

	Unoperated No. Cases	Operated No. Cases
Symptomatic { Non-contributory.....	None	9
{ Contributory.....	12	5
Asymptomatic { Non-contributory.....	6	0
{ Contributory.....	None	0

The following is a list of causes of death in the patients operated upon:

1. Massive and extensive subphrenic abscess following drainage of common hepatic duct and appendectomy

2. Postoperative biliary fistula (common bile duct); obstructive jaundice; intra- and extrahepatic calculi

In the patients not operated upon common duct stones were the causative factor of death in twelve who had symptoms referable to the gallbladder; in no case in this group did it not bear relationship to death. In the six patients not operated upon who had no gallbladder symptoms there was no causal relationship between the common duct stones and death. Obviously all of the fourteen patients operated upon had gallbladder or common duct symptoms. Of this group, common duct stones were the contributing factor in five and non-contributory in nine patients who died.

A follow-up survey of the clinical cases yielded the following information: We tried to contact all but succeeded in reaching only four of the male patients and eleven of the female patients. Of the male patients two had had a cholecystectomy and choledochostomy and they reported no symptoms since operation. One of the two reported occasional heartburn and eructations after fried foods. One patient with a clinical diagnosis of common duct stones but who refused operation and signed out against advice reported no symptoms since discharge from the hospital. The fourth patient died six years after his discharge from the hospital and the cause of death was cerebral hemorrhage. He had developed jaundice with pain eight months after cholecystectomy. The jaundice had subsided spontaneously and he was not operated upon. He had no gallbladder symptoms since his discharge from the hospital.

Of the eleven female patients seven had had a cholecystectomy and choledochostomy. Two had reported no symptoms since operation. Two had refused operation and had signed out against advice. On these two cases the diagnosis of common duct stone had never been proven. They reported no symptoms since discharge. One patient had had a cholecystectomy elsewhere in 1917. Her diagnosis at this hospital in 1937 was that of common duct stone. She refused operation and left the hospital against advice. She died in

October, 1949

1945 of cerebral hemorrhage. Another patient with a similar diagnosis, who also refused operation, died three years later of a cerebral hemorrhage. Neither one of these patients had any symptoms referable to the bile duct system since discharge from the hospital. It is worthy of note that three of these patients died of cerebral hemorrhage.

Though apparently entirely dissociated, the common involvement of cholesterol metabolism in gallbladder disease may have atheroma as a similar expression of this impaired function. Atheromatous vascular disease with its complications of cerebral hemorrhage and coronary arterial sclerosis may represent a parallel manifestation on this basis.

#### SUMMARY

1. A statistical review is presented of fifty-nine cases of clinical common duct stones and thirty-three cases of common duct stones found at necropsy with and without symptoms.
2. A resumé of the need and the indications for common duct exploration is listed.
3. A follow-up review of the clinical material is discussed, showing the need for early operative interference and the urgency of common duct exploration in a large percentage of cholecystectomies.

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# PERFORATED GASTRODUODENAL ULCER

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IN 1880 Miculicz performed what was probably the first surgical closure of a perforated peptic ulcer.<sup>1</sup> Although only simple plication was done, the patient died within three hours. This brief case history

TABLE I

Sex	Location of Ulcer	No. of Cases	Per Cent
Male.....	Gastric	33	30.6
	Duodenal	68	62.9
Female.....	Gastric	5	4.6
	Duodenal	2	1.8

serves to introduce a subject which is of perennial interest because of its dramatic onset, well defined surgical treatment and serious potential complications.

The original data upon which this study is based has been taken from the records of

TABLE II  
SEASONAL VARIATIONS

Season	No. of Cases	Per Cent
Winter.....	30	27.8
Spring.....	26	24.1
Summer.....	26	24.1
Fall.....	24	22.2

Highland Hospital of Rochester from 1924 through 1947, providing 112 cases of which 108 patients received surgery. The cases consist of only acute intraperitoneal perforations of gastric or duodenal ulcers.

Possible etiologic factors correspond in general to figures presented in other studies. The incidence of perforated duodenal ulcer is most common in males. (Table I.) Seasonal variation has been minimal and shows no statistical significance.<sup>2</sup> (Table II.)

The absolute incidence of peptic ulcer in

males has increased greatly according to De Bakey's analysis of 20,000 collected cases from 1910 to 1925; the increase has continued to 1940 with a relative increase in frequency of perforation.<sup>1</sup> Raw confirms this for the years 1937 to 1931.<sup>3</sup>

TABLE III  
AGE GROUP

Age	No. of Cases	Per Cent
20-29	11	10.1
30-39	25	23.1
40-49	29	26.8
50-59	23	21.3
60-69	15	13.9
70-79	4	3.7
80-89	1	0.9

Ages thirty through fifty-nine show the highest incidence of perforations. (Table III.) In this series the youngest patient was twenty-one and the oldest eighty-three. Variations from these data usually appear in a more selected group such as the male series taken from the Royal Navy by Wakeley where the average age was thirty-two and the incidence of the gastric variety 54 per cent.<sup>5</sup>

Although difficult to classify, psychic factors such as worry and overwork, which contribute to the formation of a peptic ulcer, undoubtedly have a role in the etiology of perforation. The facts also point to the concept of overload of the stomach as an etiologic consideration. This is borne out by 30 per cent of the patients with adequate histories of having eaten within two hours of onset of symptoms.

A history of previous ulcer diagnosis or symptoms was definite in two-thirds of the 108 patients subjected to surgery. Nineteen patients gave a suggestive history, seven admitted hematemesis or tarry stools,

while six had no previous abnormal gastrointestinal history.

Without exception the onset of abdominal pain in our cases was sudden and severe. (Table iv.) Radiation occurred variously to the shoulders, generally over the abdomen, to the right lower quadrant and to the back.<sup>3,6</sup> Radiation to the right lower quadrant due to spread of alimentary contents down the right gutter presented the most confusing picture noted in differential diagnosis. Of the thirty-nine patients questioned concerning vomiting, 74 per cent admitted at least one emesis and about 50 per cent had repeated emesis.

Bleeding accompanying perforation has been described by many authors who state that it rarely occurs, Olson and Nogore quote Mayo as describing an avascular spot on the anterior wall of the first part of the duodenum which appears when that organ is put on a stretch. This is said to be the most common site of a perforated peptic ulcer and is probably responsible for the dictum that a bleeding ulcer never perforates and a perforated ulcer seldom bleeds. Olson and Nogore report 13 per cent of their 166 patients as showing evidence of bleeding.<sup>7</sup>

*Physical Examination.* Some of the physical findings as reported in the earlier literature have been questioned by later writers.<sup>4,7</sup> One of these is the early presence of shock. Olson and Nogore state that shock as measured by blood pressure and pulse determinations is not a common finding and they rely on readings of hemoglobin and hematocrit to prognosticate it.<sup>7</sup> Estes and Bennett report that 76 per cent of the patients in a series of 80 cases had an initial systolic pressure over 110 mm.<sup>8</sup> In our series only six patients had an initial systolic pressure of less than 100 mm. and the pulse was recorded as greater than 110 in only eleven cases.

In spite of the fact that many of these patients had a duration of symptoms of more than six hours, subnormal temperatures were recorded in almost one-third.

Of proven value is the finding of tender-

ness and rigidity of the epigastrium. All patients in this series showed rigidity of marked degree and only one had no tenderness.

Pneumoperitoneum is another sign which is universally sought in establishing the

TABLE IV  
SYMPTOMATOLOGY

Symptom	Present	Absent	No Record	Per Cent Present
Pain				
General abdomen.....	107	1	0	98.9
Right lower quadrant..	33	6	69	84.6
Shoulder.....	20	7	81	74.1
Right.....	13			
Left.....	2			
Both.....	5			
Tenderness.....	107	1	0	98.9
Rigidity.....	108	0	0	100.0
Liver dullness diminished	16	6	76	72.7
Vomiting.....	54	19	35	73.9

diagnosis of a ruptured viscus. Clinically, this was positive in sixteen and negative in six patients. Of thirty-seven patients subjected to x-ray study, eighteen showed free air, seventeen were negative and two were equivocal. Part of the difficulty in the demonstration of this sign may be that four or five minutes on the left side is required to allow the air which may be partially trapped to collect in a position accessible to percussion.<sup>6</sup> If air is sought in a vertical plane, the head of the table should be elevated at 60 degrees for physical examination but at 90 degrees for x-ray examination. Suggestions have been made regarding the deliberate introduction of air into the stomach through a Levin tube but the attendant hazard of spillage, in the opinion of several authors, outweighs the possible diagnostic advantage. Of some practical assistance may be a peritoneal tap which also has been used in combination with the placement of 1 or 2 ounces of aqueous methylene blue in the stomach.

Peristaltic sounds were absent in all of the twelve patients in whom this sign was sought. Olson and Nogore reported 72 per

cent of the patients in their series had no audible peristalsis.<sup>7</sup> Absence of peristalsis is generally considered a reflex manifestation originating from the profound peritoneal insult of gastroduodenal leakage. The shortest time after perforation in

TABLE V  
MORBIDITY

Cause	1924- 1947	1938- 1947
Pneumonia.....	11	1
General peritonitis.....	14	1
Wound infection.....	11	2
Miscellaneous.....	19	7
Wound disruption.....	5	2
	60	13

which sounds were reported absent was one hour.

*Laboratory Aids.* Reference has already been made to the use of x-ray and the determination of hematocrit and hemoglobin. The laboratory test which is most frequently sought is the total leukocyte count. In this series seventy white blood cell counts were done; of these only six were less than 10,000.

*Diagnosis.* Because of the lack of complete records in the earlier cases, it is hard to say how many perforated ulcers were originally misdiagnosed. Other series have run from 5 to 15 per cent, the most common confusion existing with acute appendicitis and acute pancreatitis. It is suggested that peritoneal tap with analysis for free acid and amylase would be a harmless and frequently informative procedure in doubtful cases.

TREATMENT

*Medical Treatment.* Medical treatment has been reported in selected cases which correspond somewhat to the ruptured appendix seen after delay. According to De Bakey minimal qualifications for non-operative treatment are symptoms of at least twelve hours' duration, when the patient feels improved and is able to rest

comfortably and the abdominal findings are not marked.<sup>1</sup> In 1946 Taylor reported a series of twenty-eight cases with medical treatment.<sup>9</sup> The only cases in which he advises surgery are those in which there is a history of food ingestion in the period immediately antedating perforation. His argument is based on the concept that the ultimate sealing agent in the closure of any viscus is the formation of fibrin plugs. When sutures are used, the small openings beside the suture material are plugged by fibrin. Along with most other surgeons he has had the experience of finding a perforation so well sealed off at the time of operation that the site was not disturbed. Evidently the patient was curing himself and was subjected to the additional hazard of useless operation. In his series there were four deaths. Of these three were due to unassociated medical conditions. The fourth was the case of a man who had ingested two bottles of beer prior to the onset of symptoms. It was thought that this addition to the normal fasting gastric contents was enough to promote the severe general peritonitis of which he died.

*Surgical Treatment.* All treatment has one object in common, to close off the perforation. The technic most commonly used in the United States is plication, usually with reinforcing sutures which anchor a free or living tab of fat over the closure.<sup>10</sup> This method was used in ninety-seven of the surgical cases in this study.

According to Neiss, Von Haberer in 1929 performed the first recorded gastric resection for perforated ulcer.<sup>11</sup> Large series of European statistics apparently indicate two unique conclusions, the high incidence of reperforations and the low mortality of primary gastric resection.<sup>12</sup> Yudin is said to have had a series of 673 cases with a mortality of 9.8 per cent and a mortality of 6.6 per cent in the last 121 cases.<sup>11</sup>

In spite of good reports from some surgeons in this country, any addition to the simplest type of repair is generally regarded as injudicious. In this connection

Graham states, "There is no place for resection or anastomosis."<sup>13</sup>

The consensus of present day authors is that the peritoneal cavity should not be drained. Citing eighty-nine cases, McCabe and Mersheimer found the mortality to be 31.8 per cent for those drained as opposed to 22.4 per cent for those not drained.<sup>11</sup> It should be taken into account that those drained were probably victims of more diffuse peritoneal soiling than the others.

**Anesthesia.** Inhalation anesthesia was used in sixty-nine of our cases, spinal with or without supplement in twenty-two and local with or without supplement in seventeen. Spinal anesthesia or comparable relaxing agents such as tubocurarine are desirable but demand considerable judgment in their use. Graham strongly advocates spinal anesthesia whenever possible, basing his opinion on studies which have shown that less vigorous respiratory movements result in a diminished soilage of the peritoneal cavity.<sup>13</sup> He also mentions that following spinal it is not unusual for free air to become trapped under the diaphragm where it may show in x-ray for periods up to six weeks. This may be confusing if reperforation or subphrenic abscess is suspected.

Local anesthesia is the method least compromising for poor risks. In the majority of our cases this had to be supplemented by nitrous oxide inhalation.

**Chemotherapy.** Chemo- and antibiotic therapy have been in general use for only the past ten years; 54.3 per cent of the patients treated during this period received one or more of these agents. To be of statistical significance regarding the value of any one of these drugs many more cases and data would be necessary.

**Complications and Mortality.** Postoperative complications were common, occurring in sixty cases. General peritonitis, wound infection and pneumonia, respectively, were the most frequent.

Hospital days per patient averaged 23.4 for the surgical series, being reduced to

18.6 if only the past ten years were observed. Recent figures quoted by McCabe and Mersheimer were 28.14.<sup>11</sup>

The over-all mortality for the 108 cases was 19.4 per cent. (Table VI.) Considering only the last 10 years, the mortality was

TABLE VI  
RELATION OF MORTALITY TO DURATION OF SYMPTOMS

1924-1947				
Hours	Patients	Days in Hospital	Died	Mortality
1-6.....	58	23.9	5	8.6
6-12.....	24	19.7	2	8.3
12-18.....	8	20.5	4	50.0
18-24.....	8	20.0	4	50.0
24 plus.....	7	32.0	5	71.4
	105*	23.4	20	19.4
1938-1947				
1-6.....	24	20.1	0	0
6-12.....	8	20.0	0	0
12-18.....	2	21.0	1	50
18-24.....	1	6.0	0	0
	35	18.6	1	2.9

\* No history of duration of symptoms in three cases.

2.9 per cent. Of the four patients treated medically, all of whom were considered hopeless, three died. The figures for the surgical cases compare favorably with any reported, the average being somewhere between 5 and 15 per cent for the past ten years.<sup>14,15</sup>

**Extended Prognosis.** Unfortunately, follow-ups of the cases in this study are almost completely lacking. Estes and Bennett discovered that 22.8 per cent of eighty cases eventuated in surgery or hospitalization for relief of symptoms.<sup>8</sup> Illingworth, Scott and Jamieson with 733 cases report that 40 per cent of the patients had a return of symptoms within one year; of these one-half were mild and one-half severe.<sup>16</sup> Major complications leading to surgery occurred in 20 per cent over a five-year period.

Wakeley in a survey of 103 cases in the

Royal Navy found that 44 per cent of these men were still serving from nine to twenty years postoperatively.<sup>5</sup> On this evidence he says that the prognosis is better than in any other type of ulcer complex.

TABLE VII  
ANTIBIOTIC THERAPY (1938-1947)

	No. of Cases
Penicillin.....	5
Sulfadiazine.....	0
Sodium sulfadiazine.....	3
Sulfathiazole.....	5
Sodium sulfathiazole.....	3
Sulfapyridine.....	0
Sodium sulfapyridine.....	1
Sulfanilamide.....	5
	<hr/> 22

Illingworth, Scott and Jamieson believe that the over-all mortality rate for the group which survived the initial hospitalization was markedly increased over the standard figures for ulcer patients. In general the prognosis was found to be best in older patients with a short dyspeptic history.

#### COMMENTS

The figures presented in the series from this hospital are indicative of those which may be expected from any private hospital in which patients are more likely to be seen early in the course of the illness and receive treatment at the hands of a relatively small group of surgeons. Especially considering the moderate use of antibiotics in the group from the last ten years, the decrease in mortality of this once dread abdominal catastrophe is now most satisfactory (Table VII).

Accurate diagnosis is the first concern. This usually can be made clinically and verified by laboratory and x-ray findings. Methods such as peritoneal tap are secondary and will be resorted to only occasionally or as a matter of academic interest.

It is important to realize that while the diagnosis is being made or verified, the general condition of the patient should be attended to in view of impending surgery. This will include gastric suction, parenteral

fluid replacement and treatment of approaching or established shock. Antibiotic therapy will usually be started in the pre-operative period. The more emphasis placed on these concepts, the less important will become the elapsed time between onset of symptoms and surgical closure.

Among the points to be kept in mind during the operation is the possibility of multiple perforations. When surgery other than plication is indicated, as with pyloric obstruction, the judgment of the experienced operator is essential.

#### CONCLUSIONS

1. Data have been obtained from 112 cases of patients with acute perforated gastroduodenal ulcers treated in Highland Hospital of Rochester during the years 1924 through 1947.

2. There has been an absolute increase in the incidence of gastroduodenal ulcer and in the relative incidence of perforation.

3. Certain decades predispose to perforation.

4. Classical symptoms and signs of acute perforation still obtain.

5. True shock is seldom present as measured by blood pressure decline and pulse elevation.

6. Positioning for longer periods may increase the accuracy of finding free air in the peritoneal cavity.

7. The primary objective of treatment, medical or surgical, is closure of the perforation.

8. Extended prognosis is worse in patients with acute perforated gastroduodenal ulcers than for those with ordinary ulcers, the best prognosis being found in the older age groups with short or absent dyspeptic history.

9. Morbidity (37.1 per cent) and mortality (2.9 per cent) figures for the last decade are most encouraging.

10. The comments indicate the optimism with which these cases are now approached in spite of the duration of symptoms.

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# EARLY AMBULATION AFTER SURGERY\*

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EARLY ambulation after surgery has come of age as a valuable aid in postoperative management. Its maturity, however, has not been attained without certain vicissitudes during its adolescence. Throughout the period of growth and development the courage of Leithauser<sup>1</sup> and Shouldice<sup>2</sup> and the physiologic endorsement of Carlson<sup>3</sup> and others have been very conspicuous. The court of public opinion, habit and tradition had to be overcome. Unfortunately, their preceptors discouraged the practice but now, after observing reports and otherwise widening their sphere of investigation, they are enthusiastic advocates of the practice.

The great surgeons of the past were excellent anatomists. Surgeons today, from expanded research in physiology and because of a better opportunity to study applied physiology which have always been closely related to planning and therapy, find that increased basic knowledge in that field is shedding new light upon many of the problems in surgery. Postoperative complications may be referred to as the major problem. It is a problem of crippled physiology caused by surgical trauma, drugs, pain, pathology disorders and nervous reactions. The point of view many of us hold is that ambulation during the immediate postoperative period does more to correct crippled respiration, circulation and digestion than any other aid or drug. Patients who are ambulatory during the immediate postoperative period exhibit conspicuous improvement both subjectively and objectively for the reason that the approach to rehabilitation is more physiologic. The time has arrived for us to accept proper exercise during the immediate postoperative period as an aid to healing and to prevent complications just

as we accept aseptic technic to prevent infection.

*Respiratory Factors.* Pulmonary secretion of fluids presents a serious problem in postoperative management. From Hilding<sup>4</sup> we have learned that by reflex action and the use of anaesthetic drugs an abnormal amount of mucus is produced. Furthermore he points out that from the same influences, viscosity of the mucus is higher than normal and often beyond the ability of the ciliated epithelium to move. Accordingly there is a firmly fixed mucous plug which changes the diameter of the bronchus. McMichel and McGibbon<sup>5</sup> have impressed upon us the effect of postural changes on lung volume. Churchill<sup>6</sup> has made many reports on the usefulness of the spirometer and by its use it is well established that vital capacity is reduced after surgery and during recumbency to the extent of about 340 cc. It is reduced because of pulmonary capillary congestion but returns to normal in the ambulatory patient in three days and twelve to fourteen days in the patient confined to bed. The standing position and walking during the immediate postoperative period stimulate the cough reflex. The diaphragm assumes its normal position and there is prompt expectoration of quantities of silver-colored mucus which may measure up to 12 cc. Atelectasis and other complications have been averted. No corroboration is needed to convince one of the value of walking and involuntary coughing when it is observed that convalescence closely parallels the return of vital capacity. The influence of walking and coughing on pulmonary physiology is direct; pulmonary ventilation is further helped indirectly by walking, a favorable influence on the circulation. It must be remembered that anatomically the respiratory system functions

\* From the Grace Hospital, Richmond, Va.

against the special handicap of draining uphill.

*Circulatory Factors.* Circulatory complications brought on by unphysiologic postoperative care are more dangerous than those complications affecting the re-

emphasize that too long a bed period is a conspicuous feature in the development of the thromboembolic syndrome. If bed rest is so favorable an influence to the development of circulatory complications, we should not hesitate to utilize simple

TABLE 1

	Cases	Threatened Atelectasis	Atelectasis	Thrombophlebitis	Phlebothrombosis	Deaths
Leithauser.....	2,547	2	0	3	0	14
Shouldice.....	3,150	0	0	0	0	1
Trice.....	433	0	0	0	0	0
Total.....	6,130	2	0	3	0	15

spiratory system and, happily, the benefits of ambulation during the immediate postoperative period are even more striking. Relative circulatory stasis initiated by surgical trauma and intensified by prolonged bed rest leads to peripheral circulatory collapse of varying degrees, thrombophlebitis, phlebothrombosis and consequent embolism for the reasons that blood volume is lost and circulation time is longer. We are obligated to de Takats<sup>7</sup> and his co-workers who reported in 1943 and 1945 their work on coagulability of the blood. They believe that at the site of trauma an enzyme, presently referred to as thrombokinase, is liberated from the tissues and is an active thromboplastic agent in the production of thrombin, an insoluble protein not found in normal blood and believed to be essential to the clotting mechanism. It is equally interesting to know about the studies of Baker and Sedwitz<sup>8</sup> on venography of the lower extremities. These studies illustrate how quickly the material is shunted out of the deep veins after walking and how slowly it moves in the absence of muscular activity.

According to Cutler<sup>9</sup> these dysfunctions initiated by metabolic and reflex changes following surgical trauma are present during the first twenty-four hours. Barker<sup>10</sup> reports one case of fatal pulmonary embolism which occurred during the first postoperative day. Our wish, therefore, is to

walking during the immediate postoperative period as a procedure that reduces and almost removes circulatory complication. Anticoagulants, prophylactic ligation, bandages and bed exercise are poor substitutes. As far as our experience goes there are few physiologic and anatomic reasons for not walking during the immediate postoperative period.

Table 1 illustrates a series of consecutive major operations. All patients were ambulatory during the immediate postoperative period. Postoperative complications are conspicuously reduced and the serious postoperative complication of phlebothrombosis did not occur.

*Gastrointestinal Factors.* The harmful effects of abdominal distention should not be accepted as an inevitable consequence of the surgical procedure but should be anticipated as a complication that greatly affects morbidity. Therefore, a plan based on better understanding of the nervous mechanism controlling intestinal motility should be made to defeat or modify it. That plan would center around the removal of inhibition to the parasympathetics. The nervous control of intestinal motor function is complex. This control is mediated through the myenteric plexus and the autonomic nervous system, the former exerting the greater influence. While motility may be restored independently of the autonomic nervous system, under ordinary conditions





FIG. 2. Illustrates a comfortable dressing, one which does not handicap abdominal respiration.

FIG. 1. This photograph of a sixty-six year old man who had a Miles' resection was taken during the fifth postoperative hour. Before walking he was in sub-clinical shock; after walking he was much restored.

the autonomic nervous system exerts favorable influence on the myenteric plexus by removing inhibition.

The same measures used to prevent re-

TABLE II

Operation	No. of Cases	Hours in Bed	Hospital Days		Complications
			No.	Average per Patient	
Herniorrhaphy . . .	67	0	234 1/2	3.5	0
Appendectomy . . .	20	0	60	3	0

spiratory and circulatory complications apply to the digestive system, the chief one being ambulation during the immediate postoperative period. Ambulation directly restores activity to the digestive tract and indirectly reduces distention by improving respiration and circulation. It contributes to the maintenance of proper pressure relationship between the abdomen and thorax and improves muscle tone.

In ambulatory patients the administration of food is guided largely by the appetite; we take that as a certain sign that motility is being restored. Enemas, there-

fore, are never required. Our patients are on regular food early and from better than average nutrition maintain nitrogen equilibrium which is an aid to healing.

Table II, Illustrates a number of patients who were ambulatory in the operating room. Immediate recoveries were excellent. In these cases the anesthetic agent was procaine, 1 per cent solution, with 3 mm. of epinephrine to each 30 cc. of solution. Stainless steel wire was used for suturing and ligation. Skin clips were used in the skin and removed in twenty-four hours. No narcotics were required, the capsule of aspirin and nembutal being adequate. Two of the patients with appendicitis required decompression and drainage. These two patients, we believe, required exercise earlier than the others in this table and from close observation the physiology of important systems was restored rapidly.

The practice of early ambulation has been in use since July, 1945. Patients who have been ambulatory during the immediate postoperative period have had surgery of the pancreas, bile tract, stomach, intestines, female pelvis and vagina, amputations of the lower extremities, female breast, thyroid gland and all types of hernias. (Figs. 1 and 2.)

It is our belief, as reported, that vital systems are crippled by surgical trauma. The crippling is thought to be functional and, if not halted, will lead to structural changes. All of these changes occur during the immediate postoperative period when

drugs and reactions have their maximum influence. Accordingly, the day of operation or, preferably, the first few hours after operation is the time to begin walking and not the first postoperative day. This is basic to the rationale of early ambulation for the physiologic reasons given. After the first day structural changes are well established and the influence of exercise could be harmful.

## COMMENT

It is difficult to convey the extremely favorable impression made on me by the departure from a firmly entrenched routine of postoperative care. The favorable reasons for this practice do not lend themselves well to any general description which equals the experience of observing these patients. Emphasis has been directed toward physiologic considerations in surgical management, especially to a routine that prevents "deconditioning."

Contraindications to early ambulation after surgery are extremely few. Clinically, profound shock and prediction of fatal outcome are the only two; technically, unanatomic incisions and poor choice of suture material.

Infection, peritonitis, fever and moderate circulatory deficiency do not contraindicate walking. The latter circumstances do, however, involve the judgment of the surgeon.

Early ambulation restores nitrogen equilibrium promptly which shortens the lag period of healing.

Local infiltration has proved to be a very satisfactory anaesthetic procedure.

## SUMMARY

1. Prolonged bed rest has been practiced because of respect for tradition and fear of complications.

2. Immobilization of surgical patients violates physiologic principles and contributes to postoperative complications.

3. Early ambulation is a logical step in the progress of surgery and offers an excellent perspective.

4. There are definite anatomic, physiologic, psychologic and economic advantages to the practice of early ambulation.

5. Review of 6,130 cases indicates that respiratory and circulatory complications have been reduced by early ambulation and voluntary and involuntary coughing.

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# PROTEIN HYDROLYSATE AS ROUTINE SUPPLEMENT TO THE POSTOPERATIVE DIET\*

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**F**OCUS of attention on correction of protein deficiency represents one of the most outstanding recent advances in the care of surgical patients. It has been shown that adequate protein nutrition is of importance in the susceptibility to shock, prevention of local or general hypoproteinemic edema, wound healing, immunity to infection and detoxication of poisonous substances. The methods of treatment for acute deficiencies such as surgical shock consist of the use of whole blood, plasma and albumin; for less acute and chronic deficiencies the use of high protein diets and protein hydrolysates. Elman and other authorities have shown that patients who receive adequate amounts of protein postoperatively usually lose very little if any weight, and have an increase rather than decrease in the level of serum albumin as compared with controls treated with the ordinary regimen.

The purpose of the present study was to determine whether it would be worth while routinely to supplement the postoperative diets at Jefferson Hospital with protein hydrolysate. It was believed that the ordinary diets administered in the surgical wards might be inadequate in protein and that routine supplementation with protein hydrolysate might produce a significant effect on the serum protein level and postoperative course of patients.

## MATERIALS AND METHOD

The dietary supplement employed in this series was "aminoids." By weight, 45 per cent of this product is protein hydrolysate consisting of amino acids and polypeptides derived from animal, vegetable

and milk sources (liver, beef muscle, wheat, soya, yeast, casein and lactalbumin) and 40 per cent is carbohydrate (dextrose, maltose and sucrose). One tablespoonful (9 Gm.) contains 4 Gm. of protein hydrolysate. It cannot be given intravenously but must be administered orally or through an indwelling tube.

No changes were made in the various diets which the patients ordinarily received postoperatively. Analysis of the regular surgical ward diet over a period of one week revealed a daily average of approximately 270 Gm. of carbohydrate, 80 Gm. of protein and 75 Gm. of fat and approximately 2,075 calories.

The study was started in April, 1945, and was conducted over a period of one year. There were seventy patients who received supplemental feedings and seventy control patients. The amount of protein hydrolysate administered was three tablespoonfuls four times a day, equivalent to 48 Gm. of protein. This was given orally whenever possible or through an indwelling tube during the early postoperative period.

The patients were selected so as to represent the common surgical conditions encountered in an ordinary hospital. (Table 1.) The appendectomy group was subdivided into patients with and without perforation. The biliary tract surgery included cholecystostomy for empyema and cholecystectomy with and without T-tube drainage of the common duct. Gastric and colon surgery consisted of anterior and posterior gastroenterostomy, subtotal gastrectomy for both peptic ulcer and carcinoma and right colectomy. Patients who underwent Miles resection for carcinoma of the rectum

\* From the Samuel D. Gross Surgical Division of the Jefferson Medical College Hospital, Philadelphia, Pa. This investigation was aided by a grant from an anonymous donor.

were listed as a separate group. The acute intestinal obstructions were caused by postoperative adhesions, strangulated hernia and intussusception. Patients in the bar colostomy group had inoperable carcinoma of the rectum, rectosigmoid, or transverse

eter. They were all personally determined as a special project by the head laboratory technician and at least half were done in duplicate. The tests were repeated approximately every other day. A total of 678 determinations were made on the control

TABLE I  
AVERAGE CHANGES IN SERUM PROTEIN LEVELS

Operations	Control Group			Protein Hydrolysate Group		
	No.	Total Protein	Serum Albumin	No.	Total Protein	Serum Albumin
Appendectomy without drainage.....	15	-0.5	-0.5	15	-0.1	-0.1
Appendectomy with drainage.....	5	+0.6	+0.1	5	+0.6	+0.2
Biliary tract surgery.....	9	-0.4	-0.4	9	-0.4	-0.4
Major gastric and colon surgery.....	10	-0.4	-0.7	10	-0.3	-0.1
Miles resection (carcinoma of rectum).....	7	0.0	-0.4	7	-0.5	-0.6
Acute intestinal obstruction.....	5	+0.7	+0.4	5	+0.7	+0.3
Bar colostomy (inoperable carcinoma).....	5	-0.2	-0.6	5	+0.2	-0.4
Gastrostomy.....	3	-0.1	0.0	3	-0.2	-0.1
Thyroidectomy.....	3	-0.4	-0.3	3	-0.2	0.0
Miscellaneous.....	8	-0.1	-0.1	8	0.0	-0.1
Total.....	70	-0.2	-0.3	70	-0.1	-0.2

colon. The gastrostomies were performed as palliation for carcinoma of the esophagus. All thyroidectomies in this series were performed for non-toxic goiter. The miscellaneous operations in the control and supplementally fed groups consisted of radical mastectomy, elective herniorrhaphy, closure of ruptured peptic ulcer, drainage of peridiverticular abscess and drainage of osteomyelitis. The control group was selected with utmost care so as to correspond as nearly as possible with respect to age, initial nutritional status, severity of the disease and type of operation performed. Patients with marked dehydration, shock, severe liver disease or diabetes were excluded because of the added variables making interpretation of serum protein levels more difficult.

In all instances the serum protein determinations included fractionation for albumin and globulin. These measurements were made by a turbidimetric method, using the photoelectric colorim-

eter. They were all personally determined as a special project by the head laboratory technician and at least half were done in duplicate. The tests were repeated approximately every other day. A total of 678 determinations were made on the control

#### RESULTS

Average changes in serum protein levels of patients in the control and supplementally fed groups between the time of admission and discharge from the hospital are shown in Table I. For the groups as a whole the slight difference of 0.1 Gm. per cent of total protein and 0.1 Gm. per cent of serum albumin in favor of the supplementally fed group is hardly significant. The two groups paralleled each other rather closely, except for those patients who underwent gastric and colon

surgery. In this operative group the average difference of 0.6 Gm. per cent in serum albumin levels in favor of patients who received protein hydrolysate is significant. It is interesting that patients in both the control and supplementally fed groups who underwent appendectomy with drainage

protein levels was not only slightly higher in the supplementally fed group but the percentage of very low levels was also slightly less in this group. These findings agree with those in Table I in which the overall change in protein levels was slightly in favor of the supplementally fed group.

TABLE II  
INDIVIDUAL CHANGES IN SERUM PROTEIN LEVELS

	Control Group				Protein Hydrolysate Group			
	Total Protein		Serum Albumin		Total Protein		Serum Albumin	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Decreased.....	32	46	36	51	33	47	34	49
Unchanged (±0.2 Gm. %) .....	15	21	12	17	16	23	14	20
Increased. ....	23	33	22	31	21	30	22	31

and operations for acute intestinal obstruction showed increases in their protein levels whereas practically all other patients showed decreases. This is due to the fact that the initial protein levels were severely depressed in these patients, and alleviation of the infection and obstruction by surgery allowed swift recovery to more normal protein levels.

The number of patients whose serum protein levels increased or decreased between the time of admission and discharge from the hospital is shown in Table II. Fluctuations not greater than 0.2 Gm. per cent were considered unchanged. Comparison of these changes in the control and supplementally fed groups shows no significant differences.

The quantitative distribution of the patients' serum protein levels at the time of admission and discharge from the hospital is shown in Table III. At the time of admission the distribution of normal total protein and serum albumin levels was slightly in favor of the supplementally fed group, but this advantage was offset by a slight increase in the number of patients with very low levels. At the time of discharge, however, the percentage of normal

TABLE III  
DISTRIBUTION OF SERUM PROTEIN LEVELS

Total Proteins (Gm. %)	Control Group				Protein Hydrolysate Group			
	Admission		Discharge		Admission		Discharge	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
6.0-8.0	25	36	19	27	28	40	26	37
5.5-5.9	15	21	12	17	9	13	11	16
5.0-5.4	22	31	25	36	23	33	21	30
4.5-4.9	3	4	13	19	8	11	12	17
4.0-4.4	5	7	1	1	2	3	0	0
Serum Albumin								
4.5-6.0	20	29	8	11	25	36	18	26
4.0-4.4	14	20	16	23	10	14	16	23
3.5-3.9	20	29	21	30	15	21	20	29
3.0-3.4	12	17	15	21	14	20	7	10
2.5-2.9	4	6	8	11	4	6	7	10
2.0-2.4	0	0	2	3	2	3	1	1
1.5-1.9	0	0	0	0	0	0	1	1

The plasma volume determinations did not significantly alter the interpretation of the serum protein levels in the control and supplementally fed groups and are therefore not reported.

There was no striking clinical difference in the postoperative course of the patients in the two groups. The total number of hospital days was approximately the same in each and the usual complications were noted with about equal frequency in each group. There was one instance of non-fatal wound dehiscence, however, in the control group and none in the supplementally fed group. In the group of patients weighed at the time of admission and discharge there was an average loss of 6.5 pounds in the control group and 5.8 pounds in the supplementally fed group.

The "aminoids"\* were tolerated without any undue reactions by sixty patients or

\* Aminoids was supplied by the Arlington Chemical Company.

86 per cent of the supplementally fed group. These patients often complained of a full feeling and needed frequent encouragement and nursing supervision to make certain that they took all of their regular hospital diet. Untoward reactions definitely related to ingestion of the protein supplement were encountered in ten patients or 14 per cent of the group. Nausea was experienced by two patients, vomiting by five and diarrhea by four. Six patients were encountered who refused to take the hydrolysate despite the utmost persuasion. Of the latter, some were used in the control group and others were excluded entirely from the series.

#### CONCLUSIONS

1. Comparing the control and supplementally fed groups as a whole, the slightly higher serum protein levels and questionably better postoperative course clinically

in the latter group are mildly encouraging but not definitely significant.

2. The definite difference in serum protein levels in favor of the supplementally fed group following major gastric and colon surgery indicates a real need for protein supplementation but in much greater amounts than used in this series.

3. Administration of "aminoids" in the dosage and manner used in this study is not warranted as a routine procedure for all surgical cases. This is not meant to refute the well established indications for protein therapy in prophylaxis or treatment of hypoproteinemic states. There is no more justification for giving protein hydrolysates routinely than for routine administration of vitamins, antibiotics or blood transfusions.

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# PREOPERATIVE BIOCHEMICAL EVALUATION OF THE SURGICAL PATIENT

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THE importance of biochemical studies on the preoperative surgical patient is a fact of accepted importance. Often the general surgeon, unfamiliar with the intricate calculations of the laboratory, is at a loss as to the proper studies necessary to determine the physiochemical harmony of the preoperative patient. It is a useless procedure to secure many laboratory studies which give irrelevant information. The purpose of this presentation is to attempt to clarify as well as to assist the surgeon in knowing what laboratory studies are necessary from a rational viewpoint.

It is an archaic procedure to study one biochemical element to the exclusion of others. By this is meant that physiologic dysfunction does not affect one aspect of blood chemistry to the exclusion of others. For this reason an intelligent evaluation of biochemical activity may be gleaned from a study of homologous related groups of blood constituents rather than from one constituent alone. This fact was clearly demonstrated in an intensive study of the physiochemical disturbance in a severe burn.<sup>1</sup>

In this study it was pointed out that even in the evaluation of the blood picture a simple red count is insufficient. The severely ill, surgical patient should have a hematocrit study, plus a red cell count and hemoglobin determination. With these available data the ratio of blood cells to plasma in terms of hemoconcentration and hemodilution is known. Thus a decision can be made as to whether whole blood or plasma should be administered.

A urinalysis is the next most frequent study requested by the surgeon. A solitary

urinalysis often is deceiving and fails to reveal valuable information. A urinary concentration and dilution test will unfold more information as to renal function than any other single urinary study. The presence of albuminuria may be physiologic or pathologic. Albuminuria of long duration is one of the hidden causes for hypoproteinemia.

Plasma protein determination is a most important biochemical study in clinical surgery. Recent studies have unfolded many postoperative complications attributed to a lowering of the normal protein level.<sup>2</sup> For specific information on hypoproteinemia it is necessary to study the blood uric acid. Previous studies of this subject brought about a differentiation between hypoproteinemia secondary to insufficient dietary protein and hypoproteinemia secondary to accelerated endogenous protein depletion. This differentiation was made possible by an evaluation of blood uric acid.<sup>3</sup>

Blood uric acid will rise in the presence of endogenous hypoproteinemia. This results from the patient's attempts at replenishing his protein deficiency through endogenous protein secured from his own body. Clinically this state is revealed in the loss of strength and weight; chemically it can be demonstrated in an elevation of uric acid. The greater the hyperuricemia the more accelerated is the rate of endogenous protein metabolism. The reason for the hyperuricemia is the fact that uric acid is one of the end products of endogenous protein metabolism.<sup>3</sup> Studies of uric acid presuppose the elimination of other causes for an elevated uric acid. In order to interpret adequately the relation

between serum protein and serum uric acid both determinations must be performed simultaneously.

A frequently requested blood study is an evaluation of the urea nitrogen. An elevation of the urea nitrogen is termed azotemia. It is of three types: prerenal, renal and postrenal. The clinical surgeon is concerned with the first and third type. The postrenal type occurs when due to some extrinsic factor there is an obstruction to the passage of urine (pelvic tumors, enlarged prostate).

Greater concern is given to prerenal azotemia. The causes of prerenal azotemia are: (1) severe vomiting, especially in intestinal obstruction; (2) loss of intestinal contents as in diarrhea or duodenal fistula; (3) acute liver damage; (4) diabetic infections; (5) shock (traumatic or postoperative); (6) diffuse burns; (7) intestinal hemorrhage (alimentary azotemia).

Surgical patients presenting any of the above problems must have blood chemical studies directed at eliminating the presence of prerenal azotemia. Loss of chlorides is a major factor in the cause of azotemia. Hypochloremia precipitates an alteration in the harmonious relationship of the internal fluid balance. This causes azotemia which is readily corrected by the intravenous administration of sodium chloride solutions.

That alkalosis may produce azotemia was revealed in patients with peptic ulcer who were receiving large doses of sodium bicarbonate. Blood studies on these individuals revealed alkalosis, azotemia and hypochloremia. For this reason a carbon dioxide combining power is a valuable asset in evaluating the acid-base balance of the blood.

Current observations on salt intolerance in the postoperative patient has brought forward the deleterious effects of sodium chloride. In the light of unpublished studies the role of sodium and chloride ions in the disturbance of normal physiology has been stressed.<sup>4</sup> For this reason accurate chloride studies must include an evaluation of

plasma sodium. These calculations will assist in the rational administration of intravenous saline solutions.

It is evident, therefore, that an intelligent evaluation of the physiochemical state of the surgical patient can be obtained only when related studies are made. Disturbances in blood chemistry rarely are solitary. Related disturbances almost always accompany physiochemical discord. When any doubt arises as to the possibility of hepatic or renal impairment, special studies should be directed at evaluation of these organs. Liver function is best studied by employing the galactose tolerance test and studying blood cholesterol in relation to cholesterol esters.<sup>5</sup>

#### SUMMARY

For an accurate determination of the physiochemical status of the surgical patient the following is advised: (1) To evaluate the blood picture employ hematocrit, red and white blood count and hemoglobin determination; (2) proper urinalysis should include specific gravity and albumin determination; (3) study of nitrogen balance implies protein determination in conjunction with uric acid value; (4) to eliminate presence of azotemia determine urea nitrogen and blood chloride estimation; (5) to rule out disturbance of acid-base balance perform carbon dioxide combining power; (6) to establish basis for water balance and for salt intolerance perform sodium and chloride studies.

The modern surgeon can no longer concern himself with the technical aspects of surgery to the exclusion of biochemical changes. The final scene in the panorama of surgical physiochemical changes has not been witnessed. No phase of clinical surgery offers greater opportunity for study than biochemical variations before, during and following surgical procedures.

By studying the biochemically related groups of the blood constituents previously mentioned, a plan is available for the intelligent evaluation of the physiochemical harmony of the surgical patient. With this



information available many disturbing complications in clinical surgery can be avoided.

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OCCASIONALLY one encounters residual stones in the common bile duct subsequent to surgery considered adequate at the time. If possible, conservative medical management should first be tried; when surgery becomes imperative, it should be as non-radical as possible. Many surgeons on finding the stones inaccessible simply insert a T tube into the common duct and thereafter instill a few centimeters of ether into it once or twice daily. Such a practice has been followed by favorable results in many cases in which surgical removal of the residual stones seemed extremely difficult or impossible. (*Richard A. Leonardo, M.D.*)

# THE SMALL BOWEL ENEMA\*

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THE purpose of this paper is to call attention to the importance of roentgenologic studies of the small intestine by means of the Miller-Abbott tube in the diagnosis of lesions of the small bowel and to present three cases in which the diagnosis was established by this method. The Miller-Abbott tube has been shown to be of definite value in deflation of the intestinal tract in cases of obstruction, in preoperative preparation of patients for abdominal surgery, in study of the physiology of absorption and excretion of the intestinal tract, and the tube has also proved useful as a method for providing nutrition in certain difficult cases. The long double lumen tube is now proving to be of value as an aid in establishing a diagnosis in certain obscure lesions of the small intestine.

The first report of deflation of the intestinal tract by intubation was presented by Kussmaul and Cahn<sup>2</sup> in 1884. Pesquera<sup>5</sup> in 1929 was probably the first to use a duodenal tube in roentgenologic studies of the small intestine. In 1934 Abbott<sup>1</sup> introduced a double lumen tube that could be passed into the small intestine. Many studies of the small bowel have been carried out since the introduction of the Miller-Abbott tube. Weltz<sup>4</sup> in 1939 presented many excellent roentgenologic studies of the small intestine by means of a duodenal tube. However, this method was unsatisfactory because of the length of the small intestine which resulted in overlapping of the shadows. Boon<sup>4</sup> reported several cases in which the double lumen intestinal tube was used in x-ray studies of small bowel lesions other than obstruction. He reported that the Miller-Abbott tube could be used in cases of partial obstruction caused by narrowing of the lumen,

angulation, persistent spasm or other defects. Golden, Leigh and Swenson<sup>2</sup> reported that no deleterious effects resulted from the injection of barium sulfate into a Miller-Abbott tube in diseases of the small intestine. They classify their uses of the Miller-Abbott tube in small intestinal studies into: (1) paralytic ileus, (2) obstruction, (3) simple obstruction without inflammation and (4) abnormal mucosal patterns such as occur in strangulation, inflammation, malignancy and intussusception.

Many authors<sup>2-5</sup> previously reported using a duodenal tube for roentgenologic studies of lesions of the small intestine. Schatzki,<sup>6</sup> however, in 1943 first used the phrase "small intestinal enema." He did much to establish the value of this technic in discovering obscure lesions of the small intestine.

Schatzki listed several advantages of the duodenal tube as a means of examining the small intestine, namely, (1) the small intestine can be seen in its entirety, (2) actual filling of small intestinal loops can be observed roentgenologically, (3) peroral examination usually results in irregular, incomplete filling of ileum, (4) adequate examination of the ileocecal valve can be accomplished and (5) the time required for examination is shortened.

The "progress meal" of barium is frequently used in studying lesions of the small intestine. Competent radiologists are able to follow a progress meal of barium by means of the fluoroscope throughout the entire small intestine. Disadvantages of this method are that it is time-consuming usually requiring a half day or more, exposes the patient to repeated fluoroscopic examination and may be definitely harmful in cases of mechanical obstruction.

There are many patients in gastrointesti-

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nal clinics who present vague abdominal complaints and in whom after the routine roentgenologic gastrointestinal studies and other laboratory procedures no diagnosis is made. Many of these patients are told that no organic lesion is present and the symptoms are attributed to functional disturbances. Some of these patients return at a later date with a definite lesion in which the diagnosis is relatively easy. Many patients with vague abdominal complaints should have small bowel enema studies when the usual roentgenologic examination fails to reveal any organic disease. These small bowel studies can be easily carried out with the Miller-Abbott tube.

#### CASE REPORTS

CASE I. E. S., a fifty-four year old white male, was admitted to the Baptist Memorial Hospital with a history of epigastric pain of eight weeks' duration. The pain was sudden in onset and very severe. At the time of onset he was hospitalized elsewhere and a diagnosis of amebiasis was made. Treatment for amebiasis resulted in a disappearance of most of the symptoms. The patient was discharged from the hospital and instructed to return for follow-up studies. Upon admission to our service the patient did not appear acutely ill other than the evidence of considerable weight loss. A mass was felt in the left lower quadrant of the abdomen. This mass was approximately 3 cm. in diameter, was not tender and was freely movable. The routine blood and urine determinations were normal. A scout film of the abdomen was made which demonstrated some air in the transverse colon but this was not suggestive of obstruction. Barium enema studies of the colon were negative. A gastrointestinal series revealed an indefinite narrowing of one loop of small intestine. This finding was not diagnostic. A small bowel enema revealed a partial obstruction of jejunum suggestive of malignancy. The patient was operated upon and a tumor of the jejunum was found. A jejunal resection was done and this was followed by an uneventful postoperative course. Pathologic examination of the specimen showed it to be a carcinoid with metastasis to regional lymph nodes.

CASE II. J. N., a sixty-seven year old white

male, was admitted to the John Gaston Hospital for hemorrhoidectomy. The patient gave a history of passing blood from the rectum for three years. At the onset of the symptoms three years before the patient was admitted to another institution in shock as a result of bleeding from the rectum. No cause of bleeding was found after repeated barium enema and gastrointestinal studies. The patient was discharged and readmitted to the same hospital a second time for the same condition, namely, shock from hemorrhage. Again all x-ray studies were negative.

The patient was seen in the University of Tennessee Medical Clinic two years after the first bleeding episode. At this time his complaint was that of epigastric pain. He was admitted to the hospital because of severe anemia. Repeated gastrointestinal studies and barium enema examinations were negative. The only physical abnormality was internal and external hemorrhoids. The patient was discharged and sent to the Proctology Clinic for possible hemorrhoidectomy and was hospitalized on September 14, 1948. Upon admission a mass could be felt in the right lower quadrant of the abdomen. Review of the previous gastrointestinal series failed to show visualization of the terminal ileum. A small bowel enema was done and a cystic mass was seen to fill with barium from the terminal ileum. The mass appeared to arise from the pelvis. The patient was explored and a cystic lesion was found communicating with the terminal ileum. The lesion was considered inoperable. However, a biopsy was taken and the pathologic report was spindle cell sarcoma.

CASE III. I. M., a sixty year old colored female, was admitted to the John Gaston Hospital with a complaint of cramping abdominal pain of one month's duration and enlargement of the abdomen for three weeks. Constipation had existed for six months and there were no bowel movements for one week previous to admission. There was an irregular, indefinite mass in the region of the umbilicus. Barium enema examination was negative and a scout film of the abdomen revealed some dilated loops of small intestine which were suggestive of partial obstruction. A Miller-Abbott tube was used for deflation and a small bowel enema study was done. This revealed a non-obstructing lesion in the ileum. At exploration an annular lesion was found in the mid-ileum.

This was removed and a side-to-side anastomosis was performed. Microscopic examination showed the lesion to be a carcinoid of the ileum.

#### COMMENT

In none of these cases was complete obstruction present. Two of the patients had been hospitalized previously and studied extensively without the diagnosis being established. Their symptoms persisted for a long period of time. All of these patients had repeated barium enema and gastrointestinal studies which were reported as negative.

We do not advocate small bowel enema studies on every patient with vague abdominal complaints. It is not believed that this means of studying the small intestine should replace methods in common use; however, it is an additional method which should be used in certain cases. We believe that patients who continue to have gastrointestinal complaints and in whom no diag-

nosis is made by routine studies should have small bowel enema studies.

#### SUMMARY AND CONCLUSIONS

1. Emphasis is placed on the importance of the Miller-Abbott tube in studying lesions of the small intestine.

2. Three cases which illustrate the value of this method in establishing a diagnosis are presented.

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# ABSORBABLE STARCH GLOVE POWDER\*

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SINCE the first report of a talc granuloma by Antopol<sup>1</sup> in 1933 an increasing number of papers have appeared concerning this serious postoperative complication. Three deaths due directly to talc have been reported.<sup>2,3</sup> The excellent studies of Seelig and his co-workers<sup>2,4-7</sup> have not only prompted surgeons to a greater appreciation of this hazard but have also stimulated and led further search for a more satisfactory substitute for talc. The characteristics of this substitute would include: (1) satisfactory flow and lubricating qualities; (2) non-reactivity in tissues, preferably by reason of rapid absorption; (3) physical and chemical stability on sterilization. (4) non-allergenic and not irritating to the skin with repeated use and (5) inexpensive and readily available.

Potassium bitartrate was found by Seelig to be satisfactory, except that this material became sticky and carmelized with over-sterilization. Starch was found to gelatinize on autoclaving but this was prevented by the addition of formaldehyde. In clinical use, however, formaldehyde treated starch caused a skin reaction on the hands of surgeons although Gottschalk<sup>8</sup> failed to obtain positive patch tests with this material.

In a search for a satisfactory substitute for talc as a surgical glove lubricant, Lee and Lehman<sup>9</sup> studied a modified starch (powder 108) which has been commercially named Bio-Sorb. According to the manufacturer, Bio-Sorb is "a biologically absorbable powder prepared from cornstarch by etherification with epichlorohydrin. The starch polymer chains are presumably cross linked by 1,3 diether glycerine groups

to the extent of not more than 2 per cent of the original starch weight. The starch derivative is mixed with magnesium oxide, 2 per cent, and contains small residual amounts of sodium sulfate and sodium chloride."

Lee and Lehman found complete absorption of this powder from the peritoneal cavity of dogs three weeks after operation without demonstrable reaction. Recent further studies by Alrich, Lee and Lehman<sup>10</sup> confirmed this. MacQuiddy and Tollman<sup>11</sup> observed in rabbits that "very little, if any" of this starch powder remained fifty-six days after subcutaneous implantation of 200 mg. pellets. Postlethwait, Howard and Schanher<sup>12</sup> noted complete absorption fourteen to twenty-eight days after the starch powder had been placed in the peritoneal, pleural and pericardial cavities, and almost complete absorption in muscle, tendon, joint and nerve of dogs. In a limited study previously reported,<sup>12</sup> absorption of the starch was erratic (as to time) from the rabbit peritoneal cavity and was complete in six days in four dogs. These studies of Lee and Lehman, MacQuiddy and Tollman, Postlethwait, Howard and Schanher, and also those of Naffziger, Ledwich, Marchi and McCorkle<sup>13</sup> with this material suggested that it was the most satisfactory substitute for talc now available, fulfilling the requisite qualifications enumerated.

The following study was carried out to determine accurately the rapidity of absorption of the modified starch glove powder number 108.

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FIG. 1. A, four days, large coalesced plaques of starch remain; B, eight days, a small plaque of starch remains on the margin of the liver; C, twelve days, no starch found.

#### METHOD

White rats weighing 250 to 400 Gm. were used. Under ether anesthesia and with aseptic technic, 0.5 Gm. of the starch powder\* was placed in the peritoneal cavity through a short left rectus incision. Cotton closure with through and through sutures was used. At two-day intervals up to twelve days the animals were killed; forty-six rats were studied. With the abdomen opened widely, the peritoneal cavity was carefully searched by gross inspection for starch powder.

**Results.** In Table 1 the results are summarized. Absorption was complete in all animals opened in twelve days and the majority of those examined at ten days. No evidence of reaction due to the starch powder was noted, such as adhesions, in-

jection, roughening of peritoneal surface, nodules or granuloma. (Fig. 1.)

TABLE 1

Days Postop.	No. Rats	Amount of Starch Remaining*				
		4 Plus	3 Plus	2 Plus	1 Plus	0
2	2	2				
4	5	5				
6	5	5				
8	12	..	2	4	5	1
10	12	..	..	..	3	9
12	10	..	..	..	..	10

\* 4 plus large plaques of starch, 3 plus one or two small plaques, 2 plus small amount or one tiny plaque, 1 plus any trace of starch, and 0 no starch.

**Comment.** From this evidence absorption of the starch powder took place between six and twelve days after implantation in the peritoneal cavity of rats. The major portion of the starch was absorbed

\* The starch powder used in this study was supplied by Ethicon Suture Laboratory, Division of Johnson and Johnson, New Brunswick, N. J.

during the early part of the period. The amount of starch powder used was the equivalent of the talc obtained by washing the outside of four pairs of rubber gloves as routinely prepared for surgical use.<sup>9</sup> As a comparison, the starch powder placed in the rats would approximate 100 Gm. in a 70 Kg. man. This certainly represented a dosage far in excess of any amount which might be introduced accidentally into tissues during operation.

*Test for Aldehyde.* Seelig<sup>14</sup> stated that with Bio-Sorb he "found evidence of the presence of an aldehyde of some sort upon treating with Schiff's reagent." No aldehyde is present in the starch powder, according to the manufacturer's statement, so that a positive test required further investigation. In Kamm's publication<sup>15</sup> precautions regarding falsely positive tests with Schiff's reagent are given. The reagent is prepared by dissolving 0.5 Gm. pure fuchsin (p-rosaniline hydrochloride) in 500 ml. distilled water, filtering and saturating with sulfur dioxide. The latter step destroys the pink or magenta color which is restored by the addition of an aldehyde. Kamm notes that a false positive is obtained with an inorganic alkali. The magnesium oxide in the starch powder is partly converted to magnesium hydroxide in sufficient amount to cause a positive test, thus explaining the erroneous conclusion of Seelig.

To test the validity of this assumption, Schiff's reagent was added to a water suspension of chemically pure magnesium oxide. A pink color developed indicating a positive test although in no way resembling the rich purplish-red obtained with dilute formaldehyde or benzaldehyde. A suspension of the starch glove powder (5.0 Gm. in 20 ml. of water) likewise gave a faintly positive test. A test of the starch glove powder without magnesium oxide was negative.

Seelig further stated that in earlier studies he had found magnesium oxide caused granuloma and plaque formation in tissues. While tissue reaction to sufficient

quantities of undiluted magnesium oxide probably occurs, none of the workers who have studied Bio-Sorb under a variety of experimental conditions have observed failure of absorption, gross irritation or adhesion formation. Apparently the small amount of this chemical (2 per cent) contained in Bio-Sorb was insufficient to cause such reaction. To date, dogs, rabbits, guinea pigs and rats have been studied and absorption without reaction appeared to be uniform, although some variation in the time required was noted.

#### SUMMARY

A modified starch surgical glove powder was found to be completely absorbed from the peritoneal cavity of rats within twelve days. The starch powder does not contain an aldehyde, the falsely positive test with Schiff's reagent being due to the magnesium oxide. The latter, added to improve flow and prevent gelatinization was inadequate in amount to cause detectable tissue reaction.

Although the dangers of talc have been repeatedly pointed out, particularly by Seelig and his co-workers, this hazard has been allowed to remain in numerous operating rooms. The excuse that a substitute is not available is no longer acceptable. The starch powder suggested by Lee<sup>1</sup> and Lehman has been found to be extremely satisfactory as a surgical glove lubricant both in the laboratory and in the operating room.

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G. W. HORSLEY reviews the effects of hormones on cancer and notes the unfavorable results of pregnancy and active ovarian function on the prognosis of breast cancers in women. Consequently, he believes, as others did before him, that best results are obtainable by supplementing radical mastectomy with castration. He tells that 40 per cent of patients are cured by the radical operation alone whereas almost double that per cent survive the five-year period if they also are subjected to castration. Surgical or x-ray castration can be performed, of course. It is my personal preference to supplement radical mastectomy with pre- and postoperative radiation of the chest and axilla and supraclavicular region; and while the patient is undergoing such radiation, it seems simpler and safer to have x-ray castration at the same time. This has been my practice for several years past and the results have been very pleasing to me. The author mentions the possible use of male sex hormones also in these cases and it may well be worth while—but as a supplement to and not a substitute for castration. (Richard A. Leonardo, M.D.)



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# Streamlined Articles

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## THE PROBLEM OF THE REMAINING COMMON DUCT STONE\*

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A CASE is reported in which a routine cholangiogram following choledochotomy and cholecystectomy disclosed three stones still in the common duct. With the use of a biliary flush as described by Best, the three stones passed into the duodenum and were recovered from the stool. The two methods of non-operative treatment of the remaining common duct stone are discussed with their disadvantages and merits.

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One or more stones remaining in the common duct following surgery are most frequently discovered at the time of the first cholangiogram in preparation for removal of the T tube. Occasionally the surgeon may be forewarned when the patient has a recurrence of symptoms on the first clamping of the T tube. It is more common to have the patient maintain a comparatively asymptomatic course and the presence of a stone demonstrated by the roentgenologist. There is a considerable amount of dispute as to why stones in the common duct are overlooked at the time of surgery; reliable opinion concludes that either technical difficulties make choledochotomy and exploration unsatisfactory and inaccurate or that stones in the hepatic duct and intrahepatic radicles descend into the common duct after surgery. These two conditions are excellent arguments for the use of operative cholangiograms in cases in which satisfactory exploration is technically difficult. Among some of the more general

conditions that have been mentioned by other writers as reasons for leaving stones in the duct there are: the short obese patient with the deep lying common duct and considerable fat in the mesentery and around the viscera which make instrumentation difficult, palpation unsatisfactory and the examination of necessity not as thorough as one would wish; the bad-risk patient presents a definite problem as to how much of the operative time one can allocate to the ductal exploration and in some cases exploration must be hurried.

There are certain local conditions which occur in the common duct which present technical difficulties and make exploration unsatisfactory. The presence of a short common duct or a short segment between the cystic duct and the point at which the common duct disappears from view behind the duodenum offers considerable impediment to the easy passage of scoops, probes and dilators through the course of the common duct into the duodenum. The presence of an anomalous hepatic artery crossing in front of the common duct<sup>1</sup> has somewhat the same effect as a short common duct, forcing the surgeon to open the common duct within certain narrow limits and making exploration of the right and left hepatic ducts difficult. Thickening of the head of the pancreas, the result of chronic inflammation, interferes with palpation of this portion of the common duct and the probe may pass into the duodenum and the thickened tissue prevent satisfactory palpation of the duct against the probe. It

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FIG. 1. Postoperative cholangiogram demonstrating three shadows in the common duct indicative of calculi.  
 FIG. 2. Cholangiogram after biliary flush, with disappearance of shadow of three stones.

should be recognized that the passage of a probe or scoop along the common duct into the duodenum does not rule out the possibility of a common duct stone. Stones may erode into the wall of the duct, forming a pocket, and become impacted and the probe will pass satisfactorily without evidence of obstruction. Stones impacted in the region of the ampulla of Vater are among some that are commonly missed. Exploration of the right and left hepatic ducts is not usually as satisfactory as the common duct and for this reason most surgeons resort to flushing with saline in an attempt to dislodge any stones that may be present. It has been thought by many that the overlooked stone frequently comes down from the right or left hepatic duct. The fact that the stone in most cases lies

between the T tube and the ampulla of Vater, as demonstrated by the cholangiogram, would place some question on this fact. It is recognized by the writer that certain surgical maneuvers aid in overcoming the problems just mentioned such as the Kocher mobilization of the duodenum and exposure of the pancreatic portion of the common duct and supraduodenal exploration of the ampulla of Vater.

The method of handling the problem of the remaining common duct stone rests to a great extent on the presence of a T tube in the common duct. If it has been removed, surgery is the only method of treatment available. In the presence of a T tube in the common duct one of the non-surgical methods should be given a trial before operation is resorted to. There are

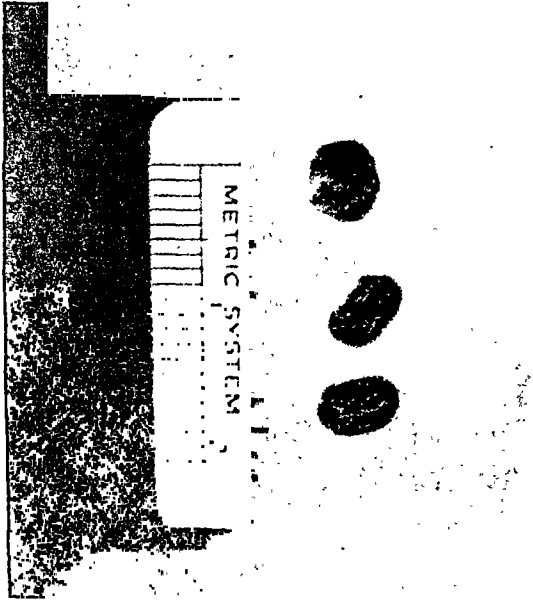


FIG. 3. Common duct stones recovered in stool following biliary flush through T tube.

two non-operative methods of handling the remaining common duct stone: (1) fragmentation and expulsion with ether; and (2) biliary flush. In 1933 and 1936 Pribram<sup>2</sup> demonstrated that gallstones contain a certain amount of cholesterol in their architecture and that cholesterol is soluble in ether. The erroneous idea has become associated with this method that the increased pressure caused by the vaporization of the ether in the common duct forces the stone through the ampulla into the duodenum. It is the slow dissolution of the stone into fragments that gives the desired results with this method. There are two disadvantages with this method of treatment, namely, the alarming abdominal symptoms that are occasionally produced in the patient by the introduction of ether and the length of time required to fragment and dissolve certain types of stones. The time required for successful trial of treatment is occasionally prolonged as some of the stone contains large amounts of calcium which are insoluble and the speed of dissolution is somewhat proportional to the amount of stone surface that comes in contact with the solvent.

Because of these apparent difficulties Best<sup>3</sup> developed a method which he calls

biliary flush and which depends most on the flushing action of warm olive oil and relaxation of the sphincter of Oddi. This method has certain advantages as it can be used quite satisfactorily through a T tube and is not painful to the patient. Amyl nitrate and other drugs are used to produce a relaxation of the sphincter of Oddi. Nupercain and other novocain derivatives have been used successfully as a flushing agent by Harris and Marcus<sup>4</sup> and others.

There is a scarcity of reports in the literature on the frequency of a stone remaining after common duct exploration. The various estimates are placed at between 10 and 18 per cent. In many of these cases the patients are reoperated upon because of a persistent biliary fistula or a return of symptoms and are, therefore, not reported.

#### CASE REPORT

Mrs. N. B., sixty-four years old, was admitted to St. Vincent's Hospital on January 28, 1947, with a diagnosis of cholelithiasis and possible choledocholithiasis. She gave a history of pain in the right upper quadrant of the abdomen following the ingestion of fatty foods for the past thirty years. There was no history of jaundice, chills and fever or clay-colored stools. The past history was essentially negative. She had had two normal pregnancies. She had been operated upon previously for a urinary bladder stone.

Physical examination revealed an obese female who was not uncomfortable. Her temperature was 98.8°F., blood pressure 175/90 and pulse 76. There was no evidence of icterus. Examination of the head was negative; the pupils reacted to light and accommodation. The mouth was edentulous and the tonsils were small and atrophic. The chest was emphysematous in type, expansion somewhat limited, and both lung fields were clear. The breasts were pendulous and the nipples were retracted; there was no evidence of tumor. The abdomen was obese and there was a midline surgical scar below the umbilicus. The gallbladder and liver were not palpable; there was slight tenderness in the right upper quadrant. The remainder of the abdomen was negative to examination. On vaginal examination the uterus was small and

the tubes palpable. Rectal examination was negative.

Laboratory findings were as follows: red blood cells 3,800,000; white blood cells 6,200; hemoglobin 12.6; urinalysis negative; prothrombin 73.5; Wassermann negative; non-protein nitrogen 32; sugar 108; electrocardiogram showed premature ventricular contraction. X-rays showed multiple stones in the gallbladder; there was no evidence of myocardial damage.

The patient was operated upon February 5, 1947. The abdomen was opened through a right rectus incision and exploration revealed the presence of a small contracted gallbladder filled with stones of varying sizes. The cystic duct was dilated and there was a stone impacted at the junction of the cystic and common ducts. The liver was smaller than normal, firm and deep red; the surface was granular, suggestive of an early cirrhosis. The stomach and duodenum were normal. Inspection and palpation of the pancreas showed a small organ, freely movable; there was no evidence of inflammation. The large and small bowels were normal. The uterus and pelvic organs were small and atrophic. The common duct was enlarged and a stone could be palpated. The bile from the common duct was clear and green.

The duct was opened and explored and a single stone was removed. A T tube was sutured into the common duct, the gallbladder was removed and the abdomen was closed. The patient was given 500 cc. of blood during surgery and her immediate postoperative condition was satisfactory. The postoperative course was uncomplicated and the drain was removed on the third day; the T tube was clamped on the fourth postoperative day. On the twelfth postoperative day a cholangiogram was made before

the T tube was removed. It revealed the presence of three shadows in the common duct distal to the T tube, indicative of stones. It was decided to try a biliary flush to see if the stones would pass into the duodenum. The following three-day regimen was instituted: 3 gr. decholin three times a day;  $\frac{1}{100}$  gr. nitroglycerin three times a day; at the time the T tube was flushed with warm olive oil and magnesium sulfate (2 ounces) at 7:00 A.M. and cream (2 ounces) at 8:00 P.M. The T tube was clamped shut except for the instillation of 40 to 50 cc. of warm olive oil daily. On the second day  $\frac{1}{300}$  gr. atropine was given in place of nitroglycerin. On the second day of the treatment one stone was recovered from the stool and on the third day, two stones. Repeat cholangiograms the following day showed a normal gallbladder and bile ducts. The T tube was removed and the patient was discharged from the hospital. One year later the patient was symptom-free. (Figs. 1 to 3.)

It is believed that more frequent use of mobilization and exploration of the retro-duodenal portion of the common duct and the use of operative cholangiograms would reduce the incidence of this complication.

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# PRIMARY IDIOPATHIC SEGMENTAL INFARCTION OF THE GREATER OMENTUM\*

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*Philadelphia, Pennsylvania*

**A** REVIEW of this subject leads to the conclusion that spontaneous infarction of the greater omentum is a



FIG. 1. Photomicrograph of infarcted area of omentum showing a recent hyaline thrombus in a vein; also extravasation of erythrocytes and neutrophils;  $\times 200$ .

rare surgical lesion which, with few exceptions, simulates acute appendicitis. In eight of the ten cases reported appendicitis was the preoperative diagnosis. With that preoperative impression the real lesion may not be found during operation unless the omentum is thoroughly explored. The failure to diagnose and remove this pathologic lesion may lead to adhesions and unexplained abdominal symptoms. The etiology of this lesion is obscure but the almost constant location of the infarct suggests to us that some anatomic peculiarity of the venous drainage of the omentum, predisposing to thrombus formation in its lower right portion, may be a contributing factor.

\* \* \* \*

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The disturbance in nine of the ten cases was notably similar.<sup>1-3</sup> It consisted of a hemorrhagic infarct of the distal edge of the omentum on the right side. In one case the infarct was described as radiating from the greater curvature of the stomach.

As one would expect from the location of the disorder, the signs and symptoms of this lesion are usually not distinguishable from acute appendicitis. A preoperative diagnosis of acute appendicitis was made in eight of the cases and was mentioned in another in which the first impression was subacute perforated peptic ulcer. In the remaining case in which the infarction was near the greater curvature of the stomach the preoperative diagnosis was perforated duodenal ulcer. All of the cases diagnosed as acute appendicitis exhibited pain, tenderness and muscle spasm in the lower right quadrant occasionally associated with some indigestion. In the remaining two cases the signs and symptoms were localized in the para-umbilical or epigastric region. Vital statistics and laboratory studies were fairly constant and consistent with a diagnosis of acute appendicitis. The patients were twenty-seven to sixty-three years of age and equally distributed between both sexes.

At operation the diagnosis is not difficult to make if proper exploration is carried out when the condition of the appendix or another suspected organ is not consistent with the signs and symptoms. The omentum presented a picture of hemorrhagic infarction with varying degrees of gangrene in several specimens. The involved portion was adherent to the anterior abdominal wall in about half of the cases. An excess of peritoneal fluid or serosanguineous fluid was observed occasionally. The appendix

was never found closer than several centimeters from the involved portion and was never acutely inflamed.

The treatment consisted of excision of the involved omentum except in one instance<sup>4</sup> in which the infarction was found in its proximal portion. An incidental appendectomy was performed in all but three cases. The abdomen was closed without drainage except in that instance in which the involved omentum was not removed. Convalescence was uneventful in all cases.

#### CASE HISTORY

A fifty-four year old, white woman was admitted to Jefferson Hospital with the chief complaint of abdominal pain. Two days previously a sudden, severe, non-radiating pain had developed in the lower right quadrant of her abdomen. It persisted in varying degrees of severity but was not severe enough to confine her to bed. Self-administered enemas failed to alter the pain. There was no nausea, vomiting or change in bowel habit. She denied any history of straining, coughing, sneezing or abdominal trauma prior to onset of the pain.

Her previous medical history was negative except for mild hypertension and moderate constipation of several years' duration.

Positive physical findings consisted of a slight enlargement of the heart, blood pressure 160/100, tenderness, rebound tenderness and muscle-guarding in the lower right quadrant of the abdomen. A blood count and urinalysis at the time of the admission were normal.

A preoperative diagnosis of acute appendicitis was made and the operation performed soon after admission. Upon entering the peritoneal cavity a small amount of serosanguineous fluid was observed. The appendix appeared to be normal but an area of infarction approximately 3 by 4 cm. in the lower right edge of the greater omentum was found loosely adherent to the anterior abdominal wall. Thorough exploration revealed no other disorder. The involved portion of the omentum was widely excised and an incidental appendectomy performed. The abdomen was closed without drainage.

The operative diagnosis of primary idiopathic infarction of the greater omentum was confirmed by pathologic examination.

After an uneventful postoperative convalescence the patient was discharged on the tenth postoperative day. One month after discharge comprehensive studies to determine any abnormality of the clotting mechanism were all within normal limits. Two and a half years after operation there was no recurrence of symptoms.

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# CONSTANT PRESSURE SCALP DRESSING\*

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**O**CCASIONALLY it is necessary to have equally distributed constant pressure to the scalp. One frequent laceration of the scalp extending down to the epicranium. The laceration roughly resembled a large "D" and the flap measured 10 by 15

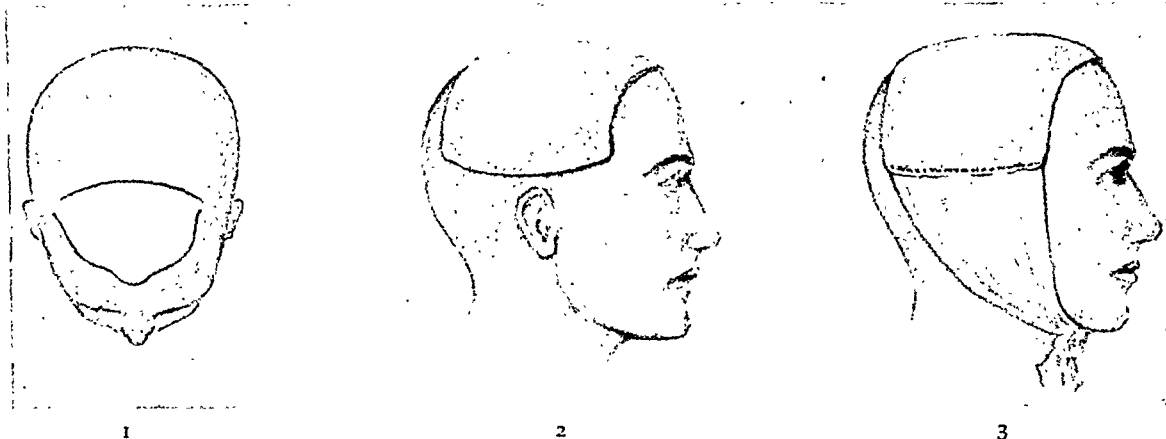


FIG. 1. Extensive laceration, roughly resembling a large D, with flap completely avulsed except for two small attachments.

FIG. 2. Thin strips of gauze are applied and held secure by sea sponge following suture of scalp edges.

FIG. 3. A piece of muslin is attached to each end of a cuff of a rubber glove, the ends of which are tied under chin for tension.

quently sees head injuries with associated extensive scalp tears. Patients so injured may be in various stages of confusion resulting from concussion. It is in this type of case that a constant pressure scalp dressing may have a place because in addition to the desired pressure, it is almost impossible for a confused patient to remove the dressing himself.

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## CASE REPORT

A thirty-six year old, white male, fell while attempting to board a moving train. He was momentarily unconscious and on admission to the hospital appeared somewhat confused. The confusion, however, was in part due to language difficulty and not entirely the result of injury.

Examination revealed a compression fracture of the bodies of the eighth and ninth dorsal vertebrae. There was an extensive

cm. The flap was completely avulsed except for two small attachments which were 1 cm. and 2 cm. respectively. (Fig. 1.) It appeared that these attachments would not be sufficient to furnish blood supply to the flap and that actually the repair would be a full-thickness skin graft. Preparation and shaving of the surrounding scalp and flap were difficult. It was feared that during the process the flap would become completely detached. To avoid this possibility the flap was secured to the scalp in several places with towel clips. The area was shaved and cleansed with soap, water and normal saline washes. The flap was then carefully sutured to the scalp edges using fine black silk. Thin strips of gauze were applied and held secure by a sea sponge. (Fig. 2.) A cuff of rubber glove to which a piece of muslin had been stitched on each end was applied and the ends tied under the chin so that a moderate degree of tension could be maintained. (Fig. 3.) A piece of stockinet was put on the head and a thin cap of plaster applied, making sure that

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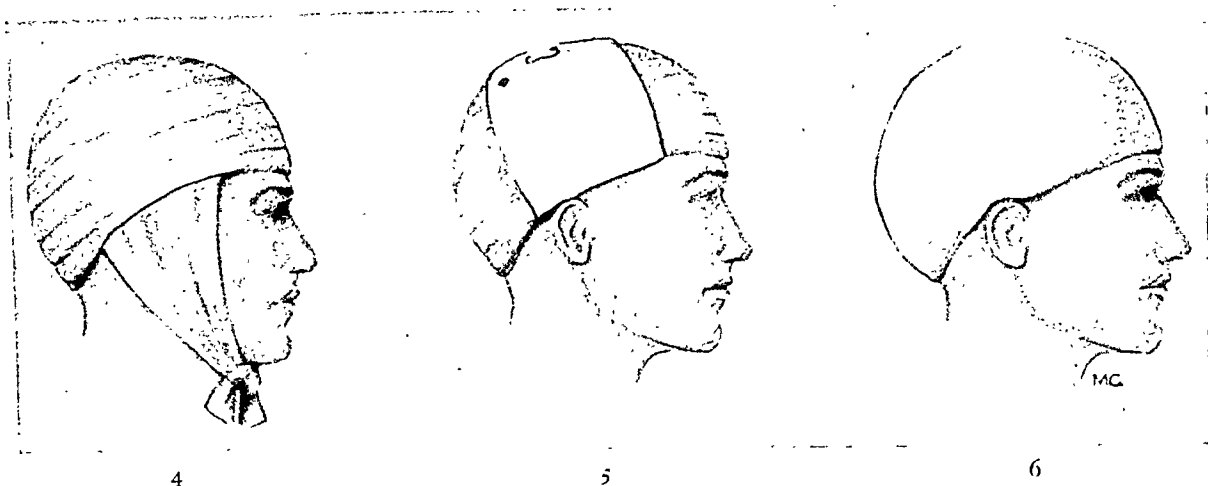


FIG. 4. A stockinette and a thin cap of plaster are applied, extending well down on the orbital ridge in front and to the external occipital protuberance behind.

FIG. 5. After the plaster has hardened, pieces of muslin are untied under chin, brought back up on top of the head and secured with a safety pin.

FIG. 6. Another thin layer of plaster completes the dressing.

it extended well down on the orbital ridge in front and to the external occipital protuberance behind. (Fig. 4.) This was done to assure good fixation of the cap below the greatest circumference of the head. After the plaster had hardened, the knot below the chin was untied. Care was employed not to relax the tension and the pieces of muslin were turned back on top of the head and secured with a safety pin. (Fig. 5.) The redundant edges were cut away. Another thin layer of plaster completed the dressing. (Fig. 6.)

The wound was left undisturbed for eleven

days; the cap was then removed. The skin of the flap was in excellent condition and the edges had healed beautifully.

The patient in this particular instance had a laceration of the center of the scalp. However, injuries to the occipital or frontal areas can be managed in the same manner. If the wound is in the occipital region, the pieces of muslin are tied below the nose; if the injury is in the frontal area, the pieces are tied at the back of the neck.





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# Case Reports

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## PLANTAR INTERDIGITAL NEUROMA OR MORTON'S TOE\*

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THIS is to represent a not too uncommon condition of the foot which is painful and at times disabling to the patient; a condition that can usually be relieved by surgery. It is known as plantar interdigital neuroma or Morton's toe.

Thomas Morton originally described this condition in 1876 at which time he suggested that it was an affliction of the fourth metatarsophalangeal joint or a pinching of the digital branch of the lateral plantar nerve by the head of the fifth on the neck of the fourth metatarsal bone. Since that time the condition has been frequently described but it remained for Letts in 1940 to stimulate its contemporary interest. He advanced a more sound etiologic theory which was a stretching and irritation of the fourth digital nerve. This nerve differs anatomically from the other plantar nerves in that it has a double origin—a branch from the medial as well as the lateral plantar nerve.

In a review of the literature it was noted that Thomas Morton described a surgical procedure for the alleviation of this condition, the excision of the fourth metatarsophalangeal joint. His description of the procedure is interesting for he emphasized the necessity to "excise all adjacent soft parts to insure excision of all surrounding nerve branches." These last two words, "nerve branches," suggest the reason for his cures.

Mills in 1888 and Hoadley in 1893 stated that the fourth digital nerve was the involved nerve, not the fifth as suggested by Morton. Hoadley was the first to suggest

that the nerve be removed but made no report of nerve resection. Hoadley in his report also suggested that a tear in the transverse ligament depressed the fourth metatarsal head and thus initiated the irritation to the digital nerve. The history of trauma arose frequently in the case reports of the older literature but has been discounted or overlooked by contemporary authors. This might bear farther investigation.

Sir Robert Jones and A. H. Tubley in 1898 noted there was a neuritis of the digital nerve and mentioned its double origin. Both are points of significance, as will be shown later, but their importance was not realized. These men condemned the resection of the digital nerve as a dangerous procedure.

It can be seen that by the work of the aforementioned physicians all the essential elements of plantar interdigital neuroma, or Morton's toe, were known by 1898. This did not, however, detract from the work done and reported by Betts of Adelaide in 1940, and by McElvenny of this country in 1943; for it was these men, working independently of each other and who, by correlation of anatomy, physical and operative findings, gave us our present concept of this pathologic condition of the foot.

### ETIOLOGY

The etiology, according to Betts, can be simplified into a few words, namely, a stretching or irritation of the fourth digital nerve due to its anatomic peculiarity. In 1948 K. I. Nissen of England presented an

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FIG. 1. Photograph of a plantar interdigital neuroma in situ demonstrating the fusiform swelling just proximal to the terminal branches of the nerve.



2

FIG. 2. Photograph of a case of bilateral plantar interdigital neuroma after removal.

article that supported the general conclusion of Betts but suggested a different primary etiology for the neuritis.

Betts suggested the following as the etiologic factors leading to plantar neuroma of the fourth digital nerve: (1) The fourth digital nerve arises from an anastomosis of a branch from the medial plantar nerve and a branch from the lateral plantar nerve. This is different than the other digital nerves which branch from either the lateral or medial plantar nerve. (2) The nerve, because of its double origin, is surrounded by more sheath. This enlarges the diameter of this certain nerve. (3) The branches from the lateral and medial plantar nerves come from above, down and around the belly of the flexor brevis muscle to join into a single nerve. This then crosses the transverse ligament to divide and supply the lateral side of the third toe and the medial side of the fourth toe. Thus, when the flexor brevis contracts, as in walking, the origin of the nerve is fixed; and with the toes in dorsiflexion the nerve is subject to stretching and trauma as it passes over the unyielding transverse ligament. Therefore, a local neuritis is evoked with swelling. This leads to more stretching and swelling, completing the vicious cycle.

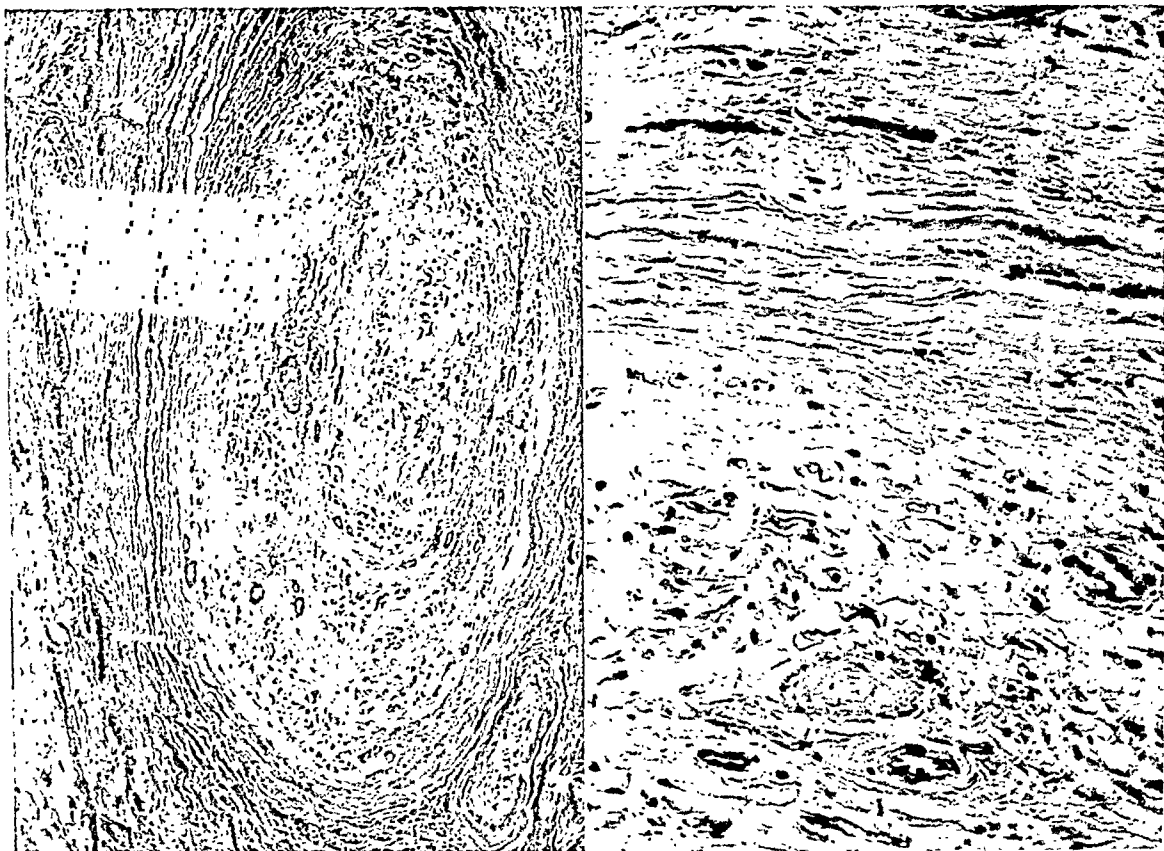
Nissen contends that the etiologic factors leading to plantar neuroma of the fourth digital nerve are not only those presented by Betts but that the primary lesion is one

of local vascular degeneration leading to a wide variety of changes in and around the nerve. In discussing the anatomy, he points out: (1) The communicating branch from the lateral plantar nerve, which is important to Bett's theory, is frequently absent. (2) The artery supplying the third interspace is sometimes absent and a branch from the artery supplying the second interspace must cross the common flexor sheath for the third toe in order to reach the nerve, thus making the artery particularly liable to pressure transmitted through the sole. (3) The micropathologic examination shows the digital artery to have advanced degenerative changes. These changes, he believes, are the primary lesion.

Nissen does not advance the reason for the degenerative change in the digital artery of the third interspace. In his opinion the arterial supply to the digital nerves are of paramount importance when compared to larger nerve branches elsewhere in the body since these larger branches always have a good anastomatic arterial supply which protect them from ischemia.

#### CASE REPORT

Patients in this group with pain or disability enough to warrant operation numbered four. All were females between the ages of twenty-nine and fifty-four. One case exhibited bilateral involvement. Be-



3

4

FIG. 3. A low power photomicrograph of a plantar interdigital neuroma showing increase in the fibrous connective tissue, thickening of the perineurium, degeneration of the nerve fibers and infiltration about these fibers with fibrous connective tissue;  $\times 10$ .

FIG. 4. A high power photomicrograph; the perineurium shows fibrotic and hyalin changes which markedly thicken the whole structure;  $\times 40$ .

cause of the similarity of these cases as to their subjective symptoms, only one will be presented. (Figs. 1 and 2.)

R. G., a white female, age fifty-one years, a school teacher, was admitted February 28, 1949. The patient gave a history of ten years' duration. It consisted of sharp, lancinating pain over the head of the fourth metatarsal. The attacks of pain came suddenly and were relieved by removing the shoe and massaging the foot. She had sought relief with orthopedic shoes, metatarsal bars and supports without the desired results.

On physical examination of the foot, tenderness on pressure could be elicited in the third interspace. Compression of the foot in the region of the metatarsal heads caused pain in the third interspace. There was hypesthesia over the lateral side of the third toe and the medial side of the fourth toe. The patient was

operated on February 29th and a digital neuroma was found and removed.

As all symptoms and physical findings in interdigital neuroma are not found in every patient, it would perhaps be in order to enumerate them.

*Symptoms.* The symptoms are: (1) Severe, sharp, burning pain in the region of the head of the fourth metatarsal. This pain can occur on weight-bearing and on non-weight-bearing, in contradistinction to metatarsalgia which is present only on weight-bearing. It can also be felt in the toes, usually the third and fourth, but at times in the second or the fourth and fifth. (2) The patient gives the history of a desire to remove the shoe and massage the foot. (3) The patient gives the history of no relief from orthopedic shoes, metatarsal

bars, arch supports, etc. All of these symptoms were present to some degree in the patients of this group. The most constant symptoms were the sharp, lancinating pain and the desire to remove the shoe.

**Physical Findings.** The findings are: (1) A normal appearing transverse arch; (2) at times tenderness is found on deep pressure over the third interspace; (3) at times a palpable tumor mass in the third interspace; (4) hypesthesia over the lateral side of the third toe and the medial side of the fourth toe, and (5) x-ray examination fails to show any evidence of bony abnormality. The physical finding of the patients of this group were by no means as numerous as mentioned above; all appeared to have a normal transverse arch. One of the four proved to have tenderness in the third interspace on firm pressure but none exhibited a palpable tumor. All patients proved to have areas of hypesthesia over the lateral side of the third toe and the medial side of the fourth toe.

#### OPERATIVE TECHNIQUE

Both plantar and dorsal approaches have been suggested but we have found a combination of both to be more satisfactory in our hands. With the use of a Boyd-Campbell tourniquet on the thigh and the patient under sodium pentothal anesthesia, an incision is made starting on the dorsum of the foot at the base of the toes in the third interspace. This is carried through the web and on to the plantar surface for about  $\frac{3}{4}$  inch. Then by blunt dissection the digital nerve is located, usually by sighting the neuroma first. The nerve is followed proximally and then distally to its terminal branches, and excised. Postoperatively the patients' courses have been uneventful and they are discharged on the fourth or fifth postoperative day. They return to the office or clinic on the tenth day for the removal of the sutures.

All patients have obtained complete relief of symptoms and have had no return of their preoperative complaints. The small plantar scar has not given any difficulty.

October, 1949

#### PATHOLOGY

On examination of the neuroma *in situ* one finds a fusiform swelling of the digital nerve just proximal to the distal bifurcation of its terminal branches. This is moderately firm to the touch and does not appear to be separable from the digital nerve itself.

The microscopic examination shows that the connection tissue about the nerve is edematous and thickened. The perineurium shows fibrotic and hyalin changes which markedly thicken the whole structure. (Figs. 3 and 4.)

The examination of the nerve fibers showed that there is a decrease in the number of fibers and that the fibers themselves are degenerative, atrophic and fibrotic.

The examination of the digital artery of the four cases disclosed only one to be thrombotic. Two others were entirely normal, while in the fourth case the artery showed degenerative changes.

#### CONCLUSION

Four cases of proven plantar interdigital neuroma have been presented. A review of the literature, etiology, symptoms, physical findings and surgical treatment are discussed.

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# TUMORS OF THE DIAPHRAGM

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**P**RI-MARY tumors of the diaphragm are unusual. Granché<sup>1</sup> reported the first one which he discovered at necropsy in 1868. Since that time almost all of them have appeared as isolated case studies. Robson and Collis<sup>2</sup> in 1944 reviewed the reports of twenty-one cases. In going through the literature we have found thirty apparently authentic cases. We did not include four others because they were based on clinical diagnoses only, and we consider the clinical diagnosis of a diaphragmatic neoplasm as necessarily somewhat inconclusive. Also, detailed information on one case reported by Nylander<sup>3</sup> in the German literature in 1942 is not available to us, so we have left it out of our summary.

Recently one of us (O. T. C.) removed a cyst of the diaphragm. There were records of three other diaphragmatic tumors in our files. Short summaries of these cases follow:

## CASE REPORTS

**CASE I.** A thirty-nine year old white woman was symptom-free but in a chest survey a lesion was found in the right lower part of the thorax and she was referred to the Mayo Clinic with the diagnosis of a probable teratoid tumor. Physical examination gave negative results. Roentgenograms of the thorax (Fig. 1) disclosed a rounded mass in the anterior axillary line just above the diaphragm on the right, with some diaphragmatic pleuritis in the area and calcification in the wall of the tumor; it was thought that the lesion probably was an infected cyst. The preoperative diagnosis was indeterminate tumor of the right lower anterior part of the thorax. At operation a posterolateral incision was made on the right, with removal of the eighth rib. The anterior part of the diaphragm was adherent to the thoracic wall with some rather dense adhesions. A firm, smooth, ovoid mass could be felt in the diaphragm. This was dissected out and removed. It left a defect

about 6 by 10 cm. in size in the anterior part of the diaphragm. This was closed with one row of interrupted and one row of continuous chromic catgut sutures. The pathologist made a diagnosis of fibrous-walled cyst containing putty-like material. (Fig. 1, inset.)

**CASE II.** A forty-five year old white woman died of peritonitis after a pelvic operation. She gave a history of tachycardia and dyspnea on exertion. A clinical diagnosis of chronic mitral endocarditis with mitral regurgitation and stenosis was verified at necropsy. A postero-anterior roentgenogram of the thorax made preoperatively did not reveal abnormal findings. At necropsy a lipoma 4.3 cm. in diameter was found in the left side of the diaphragm. (Fig. 2.)

**CASE III.** An eighty year old white woman died of cerebral vascular disease. She had generalized arteriosclerosis and diabetes mellitus. Physical examination of her thorax revealed nothing unusual, and a roentgenogram of the thorax showed only calcification of the aorta. At necropsy a lipoma 1 cm. in diameter was found in the right side of the diaphragm.

**CASE IV.** A fifty-eight year old white woman died of a dissecting aneurysm of the aorta while recuperating from a gastric operation. The physical examination and the roentgenograms of the thorax had revealed nothing unusual. At necropsy a lipoma 1 cm. in diameter was found in the right side of the diaphragm.

The case reports in the literature are summarized in Table 1. The pathologic diagnoses are shown in Table II which includes the cases reported by us. There were eighteen malignant and sixteen benign tumors. Our diaphragmatic cyst is the second one to be recorded, the first having been reported by Robson and Collis.<sup>2</sup>

Seven benign tumors of the diaphragm have been removed successfully. Five patients with malignant tumors have been operated on; three subsequently died of metastasis and two remained well.



FIG. 1. Case 1, tumor of the diaphragm; a, anteroposterior view; b, lateral view. Inset, the cyst removed at operation has been opened up.

The clinical manifestations of diaphragmatic tumors were not very characteristic. However, some of the complaints recurred in most of the cases and therefore may be briefly summarized. Usually there was more or less severe pain in the lower part of the thorax, with costal extension and with accentuation on deep inspiration. Most of the patients had a cough which, in some cases, was productive of blood-streaked sputum. In several instances the tumor was palpable as a bulging through the ribs and, in a few, an upper abdominal mass that moved with respiration was noted. In these latter instances the mass was erroneously identified preoperatively or before necropsy as a pathologic condition of the liver or spleen. Frequently, the benign tumors presented no symptoms whatsoever.

It is most difficult to diagnose a diaphragmatic tumor from the usual roentgenograms of the thorax. With a large tumor a mass may be seen but its identity cannot be definitely established as separate

from surrounding structures. Roentgenoscopy will reveal that its movement is synchronous with that of the diaphragm.

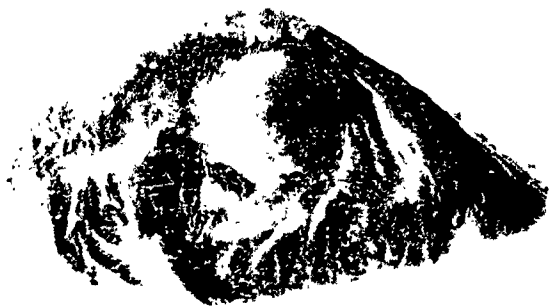


FIG. 2. Case 11, lipoma of the diaphragm removed at operation.

Artificial pneumothorax, if possible, will separate the lung from the diaphragm, and in certain instances, as described by Söderlund,<sup>15</sup> will allow thoracoscopic examination with visualization of the tumor. Pneumoperitoneum, as described by Binney,<sup>31</sup> will help separate the adjacent structures of the abdomen, and thus facilitate the diagnosis.

TABLE I

Author, Year	Age, Sex	Side	Symptoms	Diagnosis	Remarks
Granché, <sup>1</sup> 1868.....	M	..	Not stated	Fibroma	.....
Clark, <sup>4</sup> 1886.....	65 F	R	None related to tumor	Lipoma	Incidental finding at necropsy
Alexander, <sup>5</sup> 1896.....	....	..	Not stated	Fibrosarcoma	.....
Dalzell, <sup>6</sup> 1887.....	42 F	R	Cough	Sarcoma	Necropsy; metastasis to lung
Kramer, <sup>7</sup> 1899.....	54 M	L	None related to tumor	Chondroma	Necropsy; incidental finding
Gross, <sup>8</sup> 1911.....	30 M	R	Thoracic pain on right with deep breathing; small mass under left costal margin	Fibrosarcoma	Removed surgically; death from recurrence 7 months later
Bonamy, <sup>9</sup> 1912.....	24 F	R	Swelling between 8th, 9th and 10th ribs	Multiple fibromas (4)	Diagnosed preoperatively as hydatid cyst of liver; removed surgically; recovery
Sauerbruch, <sup>10</sup> 1913....	43 F	L	Abdominal pain; mass palpated in L. U. quadrant, moving with respiration; diagnosed splenomegaly preoperatively	Fibromyosarcoma	Removed surgically; recovery
Van Nes, <sup>11</sup> 1921.....	65 F	L	Thoracic pain on left, worse with inspiration; dyspnea; cyanosis	Fibrosarcoma	Tumor the size of a child's head found at necropsy
Burvill-Holmes and Brody, <sup>12</sup> 1932	50 M	R	None related to tumor	Angiofibroma	Found at necropsy; diagnosed before death by roentgenogram but patient soon died of tuberculosis
Müller, <sup>13</sup> 1933.....	45 F	R	None recorded	Myoblastic sarcoma	Discovered at necropsy
Kirshbaum, <sup>14</sup> 1935....	47 M	R	Thoracic pain on left with deep breathing; cough; hemoptysis; weight loss	Rhabdomyosarcoma	Discovered at necropsy; multiple metastases in both lungs
Kirschbaum, <sup>14</sup> 1935....	58 M	L	Thoracic pain; dyspnea; mass in L. U. quadrant of abdomen	Leiomyosarcoma	Discovered at necropsy; metastasis to lung
Söderlund, <sup>15</sup> 1937.....	50 F	L	Pain in left thorax worse with inspiration, extending rib	Lipoma	Surgically removed; recovery; diagnosed preoperatively with pneumothorax, pneumoperitoneum and thoracoscopy
Ballou and Spector, <sup>16</sup> 1939	45 F	L	None	Lipoma	Discovered at necropsy; incidental finding
Gale and Edwards, <sup>17</sup> 1939	54 M	R	Pain in right shoulder and right side of thorax; diagnosed diaphragmatic tumor by pneumoperitoneum	Endothelial sarcoma	Surgical removal; recovery
Kinsella, <sup>18</sup> 1939.....	62 M	R	Mass between 6th and 7th ribs in anterior axillary line; thrill and bruit over tumor	Fibromyoma	Surgical removal; recovery; large blood vessels running over the surface at site of tumor
Ryan, <sup>19</sup> 1939.....	51 F	R	Roentgenogram revealed high right diaphragm; abdominal exploration negative except for free fluid	Myosarcoma	Discovered at necropsy
Peery and Smith, <sup>20</sup> 1939	14 M	R	Pain with deep inspiration, dyspnea; tumor attached to ribs	Rhabdomyosarcoma	Discovered at necropsy
Petacci, <sup>21</sup> 1940.....	43 F	L	Dyspepsia initially; later, thoracic and abdominal pain	Fibromyosarcoma	Discovered at necropsy

TABLE I (Continued)

Author, Year	Age, Sex	Side	Symptoms	Diagnosis	Remarks
Hyman and Lederer, <sup>22</sup> 1941	73 F	R	Edema of legs; ascites; roentgenogram revealed some fluid in right base	Fibrosarcoma	Tumor encircled inferior vena cava, with thrombosis of that vessel; discovered at necropsy
Ackerman, <sup>23</sup> 1942.....	27 M	R	Pain in right lower part of thorax, productive cough, dyspnea, hemoptysis; roentgenologic diagnosis of diaphragmatic tumor with pneumothorax and pneumoperitoneum	Fibrosarcoma	Partial removal at operation; metastasis to lung; death later
Arkless, <sup>24</sup> 1942.....	45 M	L	Pain worse with inspiration; dyspnea, cough; pneumoperitoneum indicated subphrenic mass	Rhabdomyoma	Removed surgically; death from sarcoma of left part of thorax later so it probably was sarcoma
Soto, <sup>25</sup> 1943.....	14 M	L	Thoracic pain; hemothorax	Lipoma	Surgically removed; recovery
Soto, <sup>26</sup> 1944.....	14 M	L	.....	Lipoma	Removed surgically; recovery
Robson and Collis, <sup>2</sup> 1944	22 M	R	Pain in right side of thorax worse with inspiration; roentgenogram revealed oval shadow in right lower part of thorax	Cyst	Surgically removed; recovery
Rosenthal and Frisell, <sup>27</sup> 1945	80 F	R	None	Benign mesothelioma	Incidental finding at necropsy
Klassen, Patton and Bemen, <sup>28</sup> 1945	42 M	R	Presenting symptom was osteo-arthropathy; dry cough; roentgenogram revealed right lower part of thorax obliterated	Neurofibroma	Surgically removed; recovery
VanAlstyne, <sup>29</sup> 1945....	7 da. F	R	Born with grunting respirations; roentgenogram revealed triangular shadow adjacent to right diaphragm	Hemangio-endothelioma	Discovered at necropsy; tumor surrounded great vessels inferiorly
Branwood and Glazebrook, <sup>30</sup> 1946	42 M	R	Pain in right upper quadrant of abdomen; cough, hemoptysis	Mixed-cell sarcoma	Metastases to ribs, lung, aorta; discovered at necropsy

Along with tumors of the diaphragm, it is impossible to diagnose accurately a fairly high percentage of all intrathoracic lesions preoperatively even with all the clinical aids one can enlist. Today exploratory thoracotomy carries a mortality rate of less than 1 per cent in the hands of well trained surgeons. Thus, we believe that every patient who has a tentative diagnosis of a primary tumor of the diaphragm should be operated on provided his general condition is satisfactory.

## SUMMARY

Four cases of diaphragmatic tumor have been reported herein. In addition, reports of thirty apparently authentic cases were

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TABLE II  
PATHOLOGIC DIAGNOSIS IN THIRTY CASES OF  
DIAPHRAGMATIC TUMOR

	No.
Lipoma.....	8
Fibrosarcoma.....	5
Rhabdomyosarcoma.....	3
Fibromyosarcoma.....	2
Fibroma.....	2
Cyst.....	2
Mixed-cell sarcoma.....	1
Mesothelioma.....	1
Neurofibroma.....	1
Fibromyoma.....	1
Chondroma.....	1
Angiofibroma.....	1
Sarcoma.....	1
Myoblastic sarcoma.....	1
Leiomyosarcoma.....	1
Myosarcoma.....	1
Endothelial sarcoma.....	1
Hemangio-endothelioma.....	1



found in the literature. The clinical manifestations of such tumors were not very characteristic. Usually, more or less severe pain occurred in the lower part of the thorax, with costal extension and with accentuation on deep inspiration. Most patients had a cough and, in some instances, blood-streaked sputum was produced. In several cases the tumor was palpable as a bulging through the ribs; in a few, a mass that moved with respiration was noted in the upper part of the abdomen. The benign tumors often produced no symptoms whatever. Roentgenologic examination aided in establishing the diagnosis in some instances. Thoracoscopic examination, after artificial pneumothorax, sometimes was helpful. Also, in some cases pneumoperitoneum was an aid in establishing the diagnosis.

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## CARCINOMA OF THE COLON IN CHILDREN\*

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THE occurrence of carcinoma in the colon of a child has stimulated interest in this condition. It occurs with greater frequency than one is apt to think and a survey of the recent literature reveals an increasing number of cases reported. Cancer in childhood is an important health problem. It causes more deaths than pertussis, poliomyelitis, syphilis, measles and scarlet fever put together. As a cause of death it holds sixth place from the ages of ten to fourteen years.

The most common sites of carcinoma in children according to Daregon<sup>1</sup> are the bones, kidneys, eye and orbit, lymphatics and blood-forming organs, the soft somatic tissues and the nervous system. Carcinoma of the digestive tract, the most important cause of death from cancer in adults, is so rare in children that those afflicted with it are considered to be curiosities.

Coller and Berry<sup>2</sup> point out that pain or abdominal distress arising from carcinoma of the right side of the colon is often ill-defined and poorly localized. The symptoms of vague indigestion may resemble those of chronic disease of the gallbladder or recurring attacks of appendicitis. In regard to prognosis the authors state that as in cancers of other parts of the body, the younger the patient is the more rapidly the lesion tends to grow and the earlier it metastasizes. The frequent failure to diagnose preoperatively the nature of the disease indicates the lack of awareness generally of this clinical entity. Many cases had surgical intervention with the preoperative diagnosis of tuberculous peritonitis.

Bonelli<sup>3</sup> states that cancer of the colon and rectum ranks first among the digestive tract malignancies in children. In an excellent survey of the literature he found a total of 142 cases reported. He states that

males predominated more than two to one, with seventy-one males and thirty-two females in the series. The largest percentage of lesions, 73.8 per cent, was found in the descending colon and rectum.

Cancer of the colon in children has been reported in practically every year of life, with greater frequency in the second decade. Laird<sup>4</sup> emphasizes the fact that while rectal bleeding is a common symptom in adult malignancies of the colon, children have abdominal pain as a more common symptom. Vomiting and constipation are the other more common signs. He states that one case has been reported in a newborn monster and one in a three year old child.

Webster<sup>5</sup> in Australia reported a case occurring in the sigmoid colon of a nine year old girl. This patient had symptoms for two months prior to entry into a hospital. Her symptoms were intermittent abdominal pain and diarrhea with blood and mucus in the stool. Physical examination disclosed a smooth, round, tender, non-mobile mass situated in the midline in the hypogastrium. At surgery it was found that the lesion had replaced the normal mucosa for 10 cm. and caused a narrowing of the lumen. The patient had a resection and colostomy and later this was closed. She was well for over three years and then died suddenly. Metastasis was found in the right lobe of the cerebellum.

The near hopelessness of many of these cases has been pointed out. The delay and frequent misdiagnosis of these lesions may account partially for the low recovery rate.

Warthen,<sup>6</sup> in reporting a case in a fourteen year old, colored female, stated that the patient had colicky upper abdominal pain and constipation. His patient had an abdominal mass, a finding not frequently

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noted in many of the cases except when the right colon is involved. She was diagnosed preoperatively as having tuberculous peritonitis. At surgery metastatic nodes were seen involving the omentum. The extensiveness of the carcinoma when found at surgery accounts in part for the serious prognosis.

In 1938 McGuire<sup>7</sup> reported a case of adenocarcinoma of the colon in a boy of fifteen years; the lesion was located in the transverse colon as was shown by roentgen examination. At surgery this lesion was found to be annular; it partially obstructed the colon and extended to and involved the greater curvature of the stomach. A fistula had formed between the process in the colon and the process in the stomach. Unfortunately this patient had very few symptoms. He complained of pain, dull in character and transient. There was no diarrhea or constipation, no jaundice and no tarry or bloody stools. The pain was in the upper abdomen and was noted only when certain movements of the body occurred. Despite these meager symptoms the lesion had already made marked progress.

Pennell and Martin<sup>8</sup> state that a careful search of the smaller lymphatic nodes should be made. Often the larger lymphatics are free from metastases but the smaller ones, scarcely as large as peas, may be the seat of carcinoma deposits. In their study the authors found only very few cases with duration of more than seven months and they believe that prognosis of carcinoma of the colon is nearly hopeless. However, in 1946 Scholefield<sup>9</sup> reported a case in which the patient had been followed for seven years and was well at that time.

While the etiology of cancer of the colon is unknown, polyps, inflammatory lesions and adenomas are considered to be precancerous. Polyps may be single, multiple or diffuse. Bonelli<sup>3</sup> expresses the opinion that ulcerative colitis, in which constant destruction and repair occur, may result in carcinoma not infrequently in the young when the repair stage of the disease runs rampant. The two conditions, polyposis

and ulcerative colitis, occur more often in the younger age groups.

Among other proposals for cancer control in childhood, Daregon<sup>1</sup> suggests investigation and even repeated investigations in the presence of an atypical symptom complex, namely, an unusual child patient, especially the precocious or retarded child, if the departure from the normal has been increasingly apparent or if the child has periodic, vague illnesses with phases of normal health between attacks. Daregon also suggests that routine semi-annual physical examinations should be made after the age of six years.

Much improvement can be made in earlier recognition of colon malignancies by use of more frequent x-ray films and fluoroscopy. Particularly, barium and air contrast studied will be of value in locating the lesion. In the lower colon, digital examination, sigmoidoscopy and proctoscopy are of greatest value.

#### CASE REPORT

J. M., a male, aged fourteen, first started to complain in October, 1947, of a recurring, dull, colicky pain in the right side of his abdomen. His attending physician watched him for two or three weeks but the pain increased in intensity and became rather severe; it localized in the right side of his abdomen. He was operated upon by his attending physician and his appendix was removed through a McBurney incision. After he left the hospital about the fifth day his symptoms returned with even greater intensity and his abdomen became greatly distended. A second operation was performed by the same surgeon, this time through a right perimedial incision. A tumor mass was found obstructing the ascending colon and a cecostomy was performed. Relatives were informed of the seriousness of his condition. He was then transferred to another hospital under the care of one of us (R. M. B.). X-ray studies were made and a lesion in the right colon was found. It was decided that further surgery should be attempted as his cecostomy was not functioning properly. On December 15, 1947, a third operation, a palliative right hemicolectomy, was carried out as there were rather extensive node metastases.

The patient had an uneventful postoperative recovery. He regained his strength rapidly and was able to return to school. However, on January 18, 1948, he began to lose his appetite, complained of epigastric distress and later developed nausea and vomiting with rapid loss of weight. During the last week of his life severe jaundice developed and he died on February 8, 1948.

At autopsy extensive metastasis to the liver was found which was not present at the time of surgery. The jejunum was obstructed by large metastatic nodes in the mesentery. There were multiple peritoneal transplants.

The pathologic report\* of the specimen removed at surgery, December 15, 1947, was as follows: Gross, the specimen consisted of the distal 2.5 inches of the terminal ileum, cecum, ascending colon and over half of the transverse colon. At the junction of the cecum and the ascending colon there was an annular constricting mass approximately 8 cm. in diameter and 2.5 cm. in thickness. This large constricting mass had completely occluded the lumen of the large bowel. In addition it was completely extended through the bowel wall to the serosal surface where it produced multiple small nodular implants which were very pale in color. Microscopically, sections through the wall of the large bowel revealed a replacement of the normal architecture by fairly dense fibrous stroma containing numerous irregular branching glandular structures of variable size. The lining epithelium of these glands showed considerable pleomorphism. In some areas it was of a tall, columnar type; the cells were dark staining, closely packed together and the nuclei had lost their polarity. In other areas, particularly in the smaller glands, the lining epithelium was a cuboidal type with rather pale eosinophilic cytoplasm and a rather dark round nucleus. Most of the sections, however, showed a very marked degree of mucoid degeneration characterized by irregular spaces separated by a network of fibrous stroma in which there were accumulations of a very pale staining basophilic debris. The diagnosis was adeno-

carcinoma of the colon showing a mixed pattern with extensive mucoid degeneration.

#### CONCLUSIONS

1. Carcinoma of the colon in children is an infrequent entity but should be kept in mind as a diagnostic possibility in cases of persistent colicky pain, constipation, weakness and possibly abdominal mass.
2. Much of the delay which renders metastases possible and prognosis poor may be alleviated by more thorough proctoscopic and roentgen ray studies.
3. In the event of an acute condition of the abdomen which demands surgery, and no disorder is seen in the appendix, further exploration of the bowel is indicated.
4. Use of supportive treatment, sulfanilamide and streptomycin pre- and postoperatively, reduces the hazard of surgical procedure.
5. Use of barium enema is indicated in diagnosis of abdominal pathologic condition in children.
6. Another case has been added to the literature.

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\* The pathologic studies were made by Dr. Jesse L. Carr of the Franklin Hospital, San Francisco, Calif.



# SPONTANEOUS RUPTURE OF THE UTERUS\*

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**S**PONTANEOUS rupture of the pregnant uterus without apparent cause is a rare accident in obstetrics. The literature contains a small number of cases in which rupture had occurred during pregnancy or shortly after the onset of labor and in which no causative factor could be found, i.e., no uterine anomalies, uterine scar from previous sections, faulty presentation or prolonged labor.

We present the clinical findings of a primigravida with spontaneous rupture of the uterus at term followed by a repeated rupture four years later at seven months' gestation.

## CASE REPORT

A twenty-one year old white primigravida, at term, was admitted to Lake View Hospital on July 2, 1942, complaining of low back pain, pressure on her rectum and a slight amount of vaginal bleeding. She had started having mild labor pains two hours prior to admission.

Her last menstrual period occurred October 6, 1941, and the expected date of delivery was July 12, 1942. Her prenatal course was uneventful and pelvic measurements were adequate.

On physical examination the patient appeared uncomfortable, pale but she was not in severe pain or shock. Her blood pressure was 100/80. She complained of pressure against her rectum and pain in her abdomen. She preferred to lie on her right side stating that she was more comfortable in that position. The abdomen felt hard and tenderness was present on palpation of the uterus. The position of the baby could not be determined; no fetal heart tones could be heard. There was a slight amount of bleeding from the vagina. Rectal examination revealed a soft, presenting part slightly above the spines. No cervical dilatation was present.

Laboratory data were as follows: The Kahn test was negative. The urine revealed a specific

gravity of 1.022, a trace of albumin and no sugar. Her hemoglobin was 53 per cent (Sahli); the erythrocytes numbered 2,800,000; leukocytes 10,200 per cu. mm. The differential count was polymorphonuclears 82 per cent, lymphocytes 18 per cent.

An x-ray film of the abdomen in the anteroposterior position revealed a full term fetus in the breech position. The spine was bent at an acute angle with the head. In the lateral view the baby's back was found to lie toward the anterior side of the mother's abdomen. There was slight overlapping of the sutures of the skull. The limp appearance of the fetus and overlapping of the sutures were suggestive of a dead fetus. (Figs. 1 and 2.)

A diagnosis of premature separation of the placenta with a dead fetus was made. The patient was given a blood transfusion of 500 cc. and it was deemed best to deliver her by section. Operation was performed twelve hours following her admission to the hospital. Under general anesthesia and through a midline incision the abdomen was opened. An empty flattened uterus containing a complete, longitudinal, 16 cm. in length tear, through its posterior wall was present. This tear extended from the fundus to the internal os (full length of the corpus). A full term, dead male infant was found lying behind the uterus. The pelvis contained several blood clots and about 300 cc. of blood. Since this patient was a young primigravida and was desirous of having another pregnancy, the edges of the tear were debrided and approximated with three layers of No. 1 chromic sutures. The patient had an uneventful postoperative course and was discharged from the hospital on her twelfth day. She was examined two weeks later and appeared in good health.

The patient was again examined four years later (August, 1946) in her third month of pregnancy. Her prenatal course continued uneventfully until the morning of December 12, 1946, when she was again admitted to the hospital complaining of severe abdominal pain

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FIG. 1. Anteroposterior view showing breech presentation and collapse of the fetal spine.

FIG. 2. Lateral view showing slight overlapping of the skull bones. In the original film under a strong light the faint outline of the collapsed uterus can be seen anterior to the fetus.

and in shock. The blood pressure was 70/50, pulse 120 weak and thready. There was marked tenderness and rigidity of the abdominal wall together with a moderate amount of vaginal bleeding. The fetal parts could not be palpated and fetal heart tones were absent. Because of the previous history of a ruptured uterus, immediate operation was decided upon. Under general anesthesia the former abdominal scar was excised and the abdomen was opened. The posterior wall of the uterus contained a complete tear located at the previous identical site. A seven month dead male fetus in an intact amniotic sac was found behind the empty uterus. The placenta protruded through the uterine tear. A supracervical hysterectomy was performed and two blood transfusions were given. The patient made an uneventful recovery and was discharged from the hospital on her twelfth postoperative day. The uterus measured 32 by 20 by 12 cm. The tear measured 15 cm. in length and involved the entire thickness of the posterior wall. (Fig. 3.)

#### COMMENT

Data concerning the time and etiology of the rupture create the most interest. Un-  
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doubtedly, the tear occurred soon after the onset of labor pains prior to admission to the hospital and no apparent cause for the rupture during her first pregnancy could be found. The patient showed little evidence of shock and was operated upon with the tentative diagnosis of a premature separation of the placenta. The usual treatment for rupture of the uterus is immediate hysterectomy. If the rupture takes place during the first pregnancy with the loss of the baby and the patient is desirous of having a child, the tear in the uterus may be sutured. This preserves the uterus for future pregnancy and also for a possible future rupture. Suture should be restricted to uteri in which the torn edges are not too irregular or badly traumatized and in which sepsis is not present.

In a series of fifty-three cases reported by Delfs and Eastman<sup>1</sup> one of the seventeen spontaneous ruptures occurred without provocation in a thirty-four year old para v whose uterus ruptured at term before the onset of labor and there was nothing in the

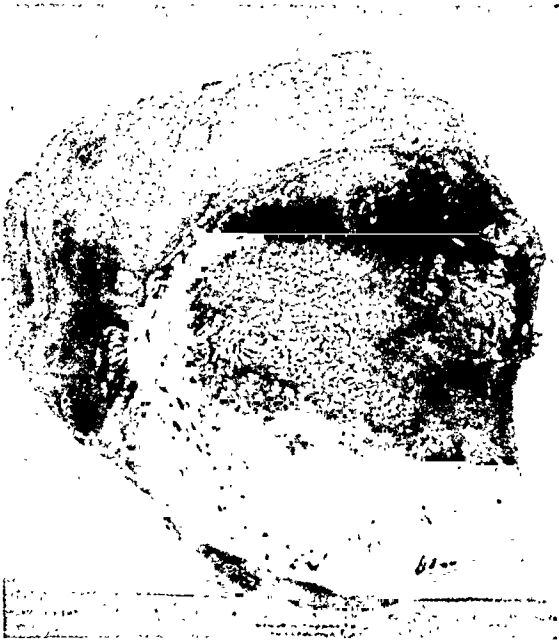


FIG. 3. Gross specimen of the uterus showing the complete rupture.

past or present history to explain the accident.

Bill, Barney and Melody<sup>2</sup> reported two spontaneous ruptures of undetermined etiology in their series of twenty-three cases. One patient was a twenty-two year old para III who died immediately after spontaneous delivery of a seven month stillborn. Autopsy revealed a complete tear. The second patient, a thirty-four year old para IV, had an easy labor and low forceps delivery, but suddenly went into shock and expired during laparotomy. Operation revealed an incomplete tear in the lower uterine segment, 6 cm. in length, located

below the bladder flap. The authors are inclined to the belief that perhaps an old cervical laceration might have given way during labor with extension of the tear into the lower uterine segment. Both of these patients had easy labors and both had uncomplicated deliveries.

Lynch<sup>3</sup> mentions a spontaneous rupture of the uterus in an early pregnancy which the pathologist reported as being due to an overactive nidation of the ovum with excessive autolysis of the maternal tissues from the trophoblastic elements. This succession of events may be an etiologic factor in some of these obscure cases.

#### CONCLUSIONS

1. No apparent etiologic factor can be found in a small number of ruptured uteri occurring during pregnancy.

2. Rupture of the uterus may occur without much evidence of shock, and the condition may be erroneously diagnosed as premature separation of the placenta.

3. The treatment of choice in a case of ruptured uterus of unknown etiology is hysterectomy since preserving the uterus may predispose to a repeated rupture.

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# INTUSSUSCEPTION IN AN ADULT\*

## PRIMARY RESECTION WITH RECOVERY AND SUBSEQUENT NORMAL PREGNANCY

WILLIAM H. PARKS, M.D. AND F. H. LASHMET, M.D.

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**I**NTUSSUSCEPTION in adults is so uncommon that diagnosis is often either unsuspected or, if considered, abandoned for the most common causes of abdominal symptoms. To date there have been reported approximately 600 cases in the world literature. These have been collected and reported chiefly by Eliot and Corscaden,<sup>1</sup> Christopher<sup>2</sup> and Nichols.<sup>3</sup> Undoubtedly, there have been many more recognized but not reported. Likewise, there have probably been others terminating fatally but attributed to other causes which were not confirmed by exploration or autopsy.

Thus far no clear and definite clinical picture of this condition has been described. Eliot and Corscaden<sup>1</sup> made the first most satisfactory attempt. Black,<sup>4</sup> in a recent report of a case, presented a brief but comprehensive review of the whole subject.

The main object in presenting another case report is an attempt to clarify the clinical picture and perhaps thereby aid in identifying more cases than are now presumed to prevail.

### CASE REPORT

The patient was a married white woman, twenty-six years of age. She had always enjoyed average health and never had any abdominal operations. In February, 1944, she contracted an acute upper infection for which one of the sulfonamide drugs was prescribed by her local physician. Recovery was complete except for a slight cough and general weakness.

A short time after this episode she experienced, for the first time in her life, epigastric distress characterized by slight colicky pains gradually increasing in intensity, reaching a maximum in a few minutes and then

spontaneously subsiding. These attacks occurred chiefly in the forenoon, seldom in the afternoon or evening and were not related to food intake. There were no accompanying nausea, vomiting, constipation or diarrhea.

After several weeks the attacks subsided sufficiently for her to resume her duties as a school teacher.

No significant changes occurred until the latter part of April, 1944. One evening she was suddenly seized with severe colicky pains in the epigastrium accompanied with nausea and vomiting. The vomitus contained food eaten earlier in the day but no blood. There had been no constipation. The patient attributed the attack to eating ice cream but this had not previously caused similar symptoms. After a few hours the attack subsided spontaneously. She restricted herself to a milk diet with no immediate recurrence of symptoms.

On April 25, 1944, she presented herself for a general examination. Further history was insignificant. The general physical examination was entirely negative. Routine urine and blood studies were negative except for a slight secondary anemia. X-ray examination of the gastrointestinal tract including cholecystograms was well within normal limits. She was advised to continue with a soft diet, frequent small feedings and iron therapy for the slight anemia. No further attacks seemed imminent.

However, on April 27th she was admitted to the hospital with excruciating, colicky pains throughout the abdomen accompanied with occasional slight emesis. The vomitus contained no blood. Prior to the attack the patient had had a normal stool containing no blood and not accompanied with any unusual symptoms. The physical examination was again negative except for slight tenderness throughout the abdomen. No one area was more tender than any other. Muscle spasm was absent and no masses were palpable.

\* From the Department of Surgery, Lockwood General Hospital, Petoskey, Mich.



The following day, April 28th, there were paroxysmal recurrence of the generalized, colicky pains in the abdomen with occasional slight vomiting without blood. Enemas gave relief with return of small particles of normal stool. The abdomen remained negative to physical examination until late in the evening. Then a large, irregular, lobulated and slightly tender mass developed in the left abdomen. It was quite high in the upper left quadrant, descended freely on deep inspiration and very strongly resembled an enlarged spleen. The patient seemed surprisingly comfortable and not particularly annoyed by abdominal examinations.

On April 29th there were no striking changes. Small amounts of clear, greenish fluid were raised but appeared to be more by regurgitation than actual vomiting. The mass in the abdomen was smaller, presented lower in the abdomen being to the left and just below the level of the umbilicus, lobulated, freely movable and only slightly tender. Muscle spasm and rigidity were absent. Blood and urine studies remained within normal limits. Small stools contained no blood. The temperature never exceeded 100.3°F. Treatment consisted of parenteral administration of fluids and sedation.

The patient continued to be quite comfortable until late in the afternoon of April 30th. Suddenly the abdominal pains recurred accompanied with emesis of dark colored fluid but without fecal odor. The stools became bloody. The abdominal mass increased in size but was no more tender than formerly and there were no muscle spasm or rigidity suggesting peritonitis. After the usual period of time the pains did not subside. Intussusception was then suspected as the cause of the obstruction but admittedly with only slight conviction. Operation was deemed advisable.

Under spinal anesthesia (procaine hydrochloride—150 mg.) with light ether supplement, abdominal exploration was undertaken by one of us (W. H. P.). An extensive intussusception of the small bowel into itself was found. The intussuscepted portion was approximately 20 cm. in length. The proximal end of the bowel appeared to be normal except for distention. No gross evidence of peritonitis was found. Inasmuch as the intussusception could not be reduced, a radical resection and side-to-side anastomosis were done.

The microscopic pathologic report on the

specimen was as follows: "Intussusception of the small intestine with infarction, gangrene and localized fibrinopurulent peritonitis. This intussusception has been occasioned by a large leiomyoma of the intestinal wall which projected into the lumen. This is a non-malignant neoplasm and the prognosis should be good except for the hazards inherent in the intussusception and the operation."

The postoperative convalescence was entirely uneventful. She was discharged from the hospital on May 24th, the twenty-fourth day after operation.

In August, 1944, approximately three months after operation the patient became pregnant for the first time. The entire prenatal course was normal. On May 28, 1945, practically a year to the day from her discharge from the hospital following the operation, she delivered a full term, normal baby. The delivery and postpartum course were without incident.

#### COMMENT

Although reports vary, it is generally conceded that approximately 60 per cent of intussusceptions are caused by tumors and these are more likely to be benign than malignant. This case is an example.

The causative agent in this case, leiomyoma of the small intestine, had undoubtedly been present for a long time but there was no evidence in the history, physical or laboratory findings to suspect it. During the period from February until April the principal symptoms were recurrent and there were colicky pains in the abdomen with vomiting, the latter being of minor importance. These signs and symptoms were not definite enough to make a positive diagnosis. Later when actual intestinal obstruction developed with the presence of a mass and melena, the causative agent was unlikely to be one of the more common ones. However, at this time operation is imperative and particularly urgent in intussusception because this is a strangulating type of obstruction and the amount of bowel involved rapidly increases. In all similar, obscure abdominal conditions, even in the absence of a mass and melena, intussusception should be suspected.

The subsequent pregnancy was quite incidental and irrelevant. But it is interesting to note that pregnancy did occur and that the intussusception with the operation did not interfere with the normal course of it.

#### CONCLUSIONS

The signs and symptoms of intussusception in adults are indefinite and confusing. Even after obstruction has obtained the diagnosis is suspected only after eliminating the more common causes of obstruction. There is no definite clinical picture unless a rather negative type

of hypothesis is assumed, namely, if an abdominal condition is not otherwise explained, it could be intussusception. The important point is to suspect intussusception and to operate at the time when a minimal amount of bowel is involved.

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HIATUS hernias are most easily repaired through the supra-diaphragmatic approach. The left eighth rib is excised and a rib spreader inserted. The sac is easily identified. It is freed from its surroundings and its contents emptied. Unless the sac is very long, it need not be excised; but its mouth or opening must be closed tightly. Interrupted silk sutures are suitable; fascial sutures may also be used. When properly repaired the new hiatus will lodge the esophagus without constricting it and will permit the surgeon to pass his finger alongside it easily, down to the abdominal surface of the diaphragm. (*Richard A. Leonardo, M.D.*)

# PLACENTA ACCRETA IN SYPHILIS

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*Catskill, New York*

IN a search of the literature only 118 authentic cases of placenta accreta have been reported according to Meyer and Ashworth's tabulation in 1940.<sup>5</sup> In 1941 Anderson<sup>1</sup> reported a case. No case of placenta accreta associated with syphilis has been reported in these cases. Lawson and Oginz<sup>4</sup> reported that John Osborne Polak of the Long Island College Hospital in Brooklyn, New York, in his thirty-four years of experience encountered only one case of placenta accreta in 6,000. Hirst found this anomaly only once in 40,000 deliveries.

Placenta accreta produces a partial or complete absence of the decidua pasalis allowing the villi to burrow directly into the uterine musculature which in turn causes the placenta to be retained in the uterine cavity. A condition producing primary atrophy of the endometrium may be the factor in producing placenta accreta. The retained placenta may be of two kinds, namely, adherent or non-adherent. The non-adherent retained type is quite common, the placenta having separated but not being expelled. A retained adherent placenta is rare but in some instances of excessive proliferation of chorionic villi the placental tissue may invade the muscular structure sometimes even penetrating the uterine wall. This is known as a true placenta accreta. If an effort is made to separate this type of placenta, the uterus may be ruptured with its dire consequences or the patient may die of hemorrhage. The only safe and practical procedure is uterine extirpation.

Factors which are reported in the literature<sup>6</sup> and believed to be of prime importance in producing placenta accreta are: previous cesarean section, too thorough

curettage, endometritis, submucous myomas and possible dyshormonism. Any condition producing primary atrophy of the endometrium might be a factor in the causation of an accreta. The chief symptom is more or less brisk bleeding when delivery of the placenta is attempted. The diagnosis is made after an attempt at manual removal has failed to establish a cleavage plane between the placenta and the uterine musculature, thereby showing retention of the placenta within the uterine cavity as differentiated from the simple retained placenta. As mentioned heretofore, immediate hysterectomy is imperative as soon as the diagnosis is made. Although several authors reported waiting for varying intervals in the presence of shock, infection<sup>5</sup> and absence of hemorrhage,<sup>5</sup> syphilis as a complication is no contra-indication to operation.

Normally the placenta is a round disc-like organ weighing about one-sixth of the weight of the infant or from 1 to  $\frac{1}{2}$  pound. The weight varies with the size of the child but may be influenced by various diseases. It measures from 15 to 20 cm., in diameter and is  $\frac{1}{2}$  to 3 cm. in thickness. One of the most notable instances of increase in weight of the placenta is found in syphilis.<sup>9</sup> Diffuse infiltrations with wandering cells, vascular changes both in the placenta and umbilical cord distinguished as elsewhere by the thickening of the adventitia and intima and curious modification of the villi consisting of new formation of loose connective tissue about the central blood vessels such as to cause a great bulbous swelling of each villus are found. Hence, there is a marked enlargement of the placenta because of the striking disproportion between the size of the uterus and

\* From the Memorial Hospital of Greene County, Catskill, N. Y.

the placenta. (Fig. 1.) In placenta accreta one sees microscopic irregular infiltration of syncytium and Langhans' cells in degenerated muscle. This anomaly is due to primary atrophy of the endometrium, the decidua basalis being absent.<sup>2</sup>

According to Meyer and Ashworth the mortality for manual removal or curettage is 58 per cent, for partial manual removal and vaginal hysterectomy 36.4 per cent, for partial manual removal and supravaginal hysterectomy 18.9 per cent, and no deaths for supravaginal hysterectomy without attempt at manual removal.

#### CASE REPORT

The following case is presented not only because of the placenta accreta and accompanying syphilis but because the case varied from the usually reported management of this anomaly:

Mrs. M. B. age forty, a white female, was admitted to the Greene County Memorial Hospital, Catskill, New York, on October 1, 1946, at 4:10 P.M. the patient stated that she was about seven months' pregnant. Two weeks prior to admission she complained of a slight bloody vaginal discharge. About a week prior to hospitalization the flow increased and she had moderate pain in the lower abdomen. She was seen by her family physician and put to bed. The following day her membranes ruptured. She had no pains on that day but on September 29, 1946, she began regular labor pains and passed a stillborn, macerated fetus of about seven months. Her physician was called and found that she had passed some clots but no placenta. A small portion of cord protruded. It was found impossible to deliver the placenta by usual means. Her flow was then moderate until she was admitted to the hospital.

Her past history showed that she had been treated for active secondary syphilis within the past year. (Table 1.) She had been given 1,200,000 units of penicillin under the supervision of the State Department of Health at Albany Hospital and discharged January 23, 1946.

Five years before she had an ectopic pregnancy followed by a right salpingo-oophorectomy. She has five children living and well,

October, 1949



FIG. 1. The fundal portion of the placenta is tightly adherent to the myometrium, extends into it and shows no clear line of demarcation.

the youngest five years of age. She had one miscarriage about nineteen years before.

On admission she appeared to be a well developed, well nourished white adult female forty years of age. Her pulse was 92, respiration 20, temperature 99.8°F., blood pressure 110/68; mental orientation was good, mental status clear. Her skin was clear with no rash. No gross deformities were noted. Examination of the abdomen showed a firm and slightly tender uterus about the size of a six months' pregnancy. The liver edge and spleen edge were not palpable. On vaginal examination the external os was about 2 cm. in diameter, soft and spongy with no tissue or cord protruding. A foul, profuse, bloody vaginal discharge was present. There were no other gross abnormal findings. The urine showed a few white blood cell clumps (regarded as 2 plus) and was otherwise negative. The Wassermann test was 10 plus, white blood cells 12,100 red blood cell 3,830,000, hemoglobin 70 per cent, polymorphonuclear, bands 40 per cent segmented 32 per cent, monocytes 1 per cent and lymphocytes 2 per cent. The previous Wassermann and point titration tests were as follows:

TABLE 1

Date	End Point Titer
1/18/46	10+
3/16/46	26
4/19/46	9
5/29/46	7
7/25/46	31
9/2/46	78
11/1/46	57

Consultation confirmed our diagnosis of true placenta accreta and hysterectomy was



FIG. 2. The myometrium is edematous and diffusely infiltrated by leukocytes of all varieties, lymphocytes and plasma cells predominating. Beneath the site of placental implantation, numerous masses of syncytial cells have invaded the uterine musculature.

decided upon. She had been given 40,000 units of penicillin every three hours since admission to the hospital. On October 5, 1946, a supravaginal hysterectomy was performed by the author. Sulfanilamide, about 4 Gm. was placed in the pelvic peritoneal cavity. The wound was closed without drainage. She made an uneventful recovery; the wound healed *per primum*. She was discharged from the hospital on the tenth postoperative day; 40,000 units of penicillin every three hours was continued until the ninth postoperative day.

On section (Lab. No. S-46-5772) the specimen consisted of a segment of uterus without cervix or adnexa that was previously opened. (Fig. 1.) Adjacent to the endometrium the endometrial cavity contained a segment of packed placental tissue measuring 7 cm. in its greatest dimension. The uterus measured 11 by 9 by 5.5 cm. The placenta was covered on one surface by a rather thin, gray-green membrane and on section was not remarkable. The attachment to the endometrial cavity at one portion showed normal demarcation from the myometrium by a thin layer of decidua and endometrium but in the posterior part of the wall in the fundal portion the placenta was tightly adherent to the myometrium and appeared to extend into it and to be rather poorly demarcated from it. The adjacent portion of myometrium was very vascular

and soft. Sections of the myometrium elsewhere showed it to be free of gross nodules.

Sections of the placenta showed chorionic villi that varied in size and shape but the majority were small. Many of the villi contained large fibroblasts with abundant eosinophilic cytoplasm. The vessels of the villi were not remarkable microscopically. The intervillous spaces were normal in size and shape.

The decidua exhibited irregularity in size and development. Some sections showed areas of well developed decidual layers but for the most part these were absent. Mostly the chorionic villi were separated from the myometrium by only a thin layer of cells that had undergone considerable degeneration and presented only nuclear remains and much eosinophilic debris. Occasional sections were noted in which this division was absent and the small villi lay in direct contact with the myometrium. The decidua was heavily infiltrated with leukocytic exudate throughout, with lymphocytes and plasma cells predominating.

Sections of the endometrium adjacent to the site of placental attachment showed only scattered areas of attempts at decidual formation and were very thin. The stroma was heavily infiltrated throughout by lymphocytes and plasma cells. The glandular elements were widely scattered and showed extensive degeneration.

The myometrium was edematous and diffusely infiltrated by leukocytes of all varieties, lymphocytes and plasma cells predominating. Beneath the site of placental implantation numerous masses of syncytial cells invaded the uterine musculature. (Fig. 2.)

Diagnosis was placenta accreta focal acute myometritis and chronic, atrophic endometritis.

The pathologic findings\* in this case indicated a diagnosis of so-called placenta accreta. The uterus showed an imperfect decidua formation and, it is assumed, this was the result of a preceding endometritis. It was of course, impossible to exclude on the basis of this study the possibility of hormone imbalance. There was certainly a failure of the endometrium to respond in the normal manner to hormonal influences preceding pregnancy or menstruation. Because of the inadequate development of decidua chorionic villi penetrated the myometrium to an unusual extent and a line of cleavage between placenta and

\* Dr. J. J. Clemmer supplied the laboratory report.

uterus was not readily formed during the third stage of labor.

#### SUMMARY AND CONCLUSIONS

1. Only 118 authentic cases of placenta accreta have been reported in the literature up to 1941.
2. No case of placenta accreta associated with syphilis has been reported to date.
3. Syphilis is not necessarily associated with placenta accreta.
4. Removal of the uterus is the only form of treatment for placenta accreta even in the presence of syphilis or other infection.
5. Penicillin is of unquestionable value prior to and following operation especially in the presence of syphilis or acute infection.

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# The Early Art of Surgery

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## FROM PAPYRI TO MANUSCRIPTS

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THE earliest efforts of the human race to record its thoughts and history for posterity were accomplished by scratching with some hard instrument on stone or bone. It is a quality of humans to be constantly alert in the quest for improvement. That is why the Assyrians developed the idea of scratching, or rather tracing, pictures and patterns on clay tablets, then baking them. The earliest known description of infantile paralysis exists in one of these Assyrian baked tablets, about 4,000 years old, and ingenious indeed is the crutch devised to hold the withered leg.

Because it was difficult to trace a curve on stone and easier to do a straight line, all early inscriptions tend to be straight, acute or obtuse angles. This was a handicap and a challenge. Almost anywhere and everywhere, particularly along river banks, a common reed grew with an inner lining which could be cut into strips substantially wide and long. A single layer was too fragile to take ink but when another layer was laid on crosswise and then the two pressed together by soaking the whole in water and letting it dry, the resulting product served its purpose well. We have discussed in previous chapters the three most important papyri of surgical interest, the Ebers, the Smith and the Hearst. As the years went by and the papyrus dried out, it crumbled like dried leaves and it is indeed a wonder that such papyri as the aforementioned have survived to our day, particularly in the fine state of the Ebers.

It was only natural that a more adaptable and satisfactory material should be found. The skin of animals, particularly

the inner lining layer, could be prepared in such manner that it would take any kind of pen or stylus stroke. The skin of the sheep and the young calf with its finer qualities was called vellum. Because the costs of production were very high, only the very finest or most important of documents could be recorded on such materials. Fortunately for the world we have access to a moderately large number of manuscripts so that instead of three, as in the case of the papyri, we have many to choose from even in the sharply limited field of those pertinent to surgical art.

Costs of getting together and binding a manuscript in those early days were so prohibitive that only the very wealthy could indulge themselves in the task. Otherwise an "angel" had to be found who would subsidize the costs. An occasional wealthy family, looking for a royal favor in the form of a higher title or a desirous land grant, would pay the costs and then present the bound manuscript as a gift to the king on his birthday or some suitable occasion. An occasional individual of great wealth, wishing to justify his place in the social scheme or aspiring to pose either as of the intelligentsia or a patron of arts and letters, would pay a stiff price for the original material, a stiffer price for the binding and putting together of the material, have the text extravagantly illuminated and illustrated, then simply run wild adorning the binding with hand-wrought silver, gold, silks, brocades and inlaying precious stones here and there.

The word manuscript translates itself by dividing into two parts, "manu" by



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The oldest known illustration of infantile paralysis.

hand and "script" written. It is easy to see why only one copy was usually made, the expense plus the painstaking labor involved too often being difficult hurdles to overcome. However, if the text was something for which there was a demand (often this would be a medical or surgical text) custom demanded that it be available for consultation by those needing to do so. It was, therefore, placed in a library, usually that of the wealthy patron who had paid the costs. A hand-forged, heavy iron chain was attached to it, so that one might consult it but could not carry it away. Could this be a reflection on the people and the times?

Many chapters, even a volume or two, can be written about chain books but very few of them were of surgical import. Two

or three of them had extensive rules of daily hygiene, chapters titled "Ars Vivendi," The Art of Living.

There is much of romance and imagination in the acquisition of a papyrus. For example, take the swarthy stranger with the intriguing wink who approached Ebers and swore that he had found the papyrus resting between the legs, under the scrotum of a mummy that had been unearthed on an expedition with which he had served as an interpreter. Chances are a native had come up with the find and the wily one took over from there, concealing the papyrus in the voluminous folds of his garment. Maybe he was even kind enough to give the finder a few shekels and tell him to get on his way and forget that he had ever seen anything.



The Smith surgical papyrus was obtained legitimately and it was only a question of bargaining and price. The Hearst papyrus passed through many hands and, as expected, found its way into a rich man's collection, but at a fancy price.

Another papyrus of later day, about 400 B.C., containing more medical lore than surgical interest, was found by a well known book collector as he visited the library of a Moravian Monastery. Coming down a ladder from a high shelf, a monk passed with a basket full of sheets which he threw into a fireplace preparatory to building a fire. Before he could light it, the book collector picked up a couple of the

sheets and almost passed out in a fit of apoplexy. Several baskets of similar sheets had been burned on previous days. In this one particular basket alone was the original New Testament written in Greek, many, many pages of an old herbal, a "philosophia" and an "Ars Chirurgia." Elaborate on that happening a few times using a free play on the imagination; what may we have as a final result?

Take a look at the cupidity of man. When the book collector offered to buy the sheets, the monks became suspicious, retrieved the whole thing, basket and all, and would not sell at any price. What was that surgical text? We'll never know.



K. LIAWAAG recommends partial pericardiectomy for constrictive pericarditis and he has had several successful results. The author likes the dorsolateral transpleural incision since this gives an excellent approach to the heart. He advises that the operation be performed *before* an unchangeable pathologic condition develops in the heart muscle and liver; it is a good suggestion. A. Yodice studied seven cases of Pick's diseases (compressive pericarditis) and reports that tuberculosis was the etiologic agent. As the fibrosis increases, the diastolic action of the heart is interfered with, Yodice reminds us; and this is followed by enlargement of the liver and, later, portal hypertension with ascites. It is for these reasons that Liawaag heartily recommends that ample partial pericardiectomy be done *early* before the onset of these irreversible pathologic changes. (*Richard A. Leonardo, M.D.*)

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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-eighth Year of Publication

VOL. LXXVIII

NOVEMBER, 1949

NUMBER FIVE

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## Editorial

### PRESIDENTIAL ADDRESS

PAUL B. MAGNUSON, M.D.

*Washington, D. C.*

I SHOULD like first to thank the officers of the Association for their cooperation during my term of office. This is a marvelous group with whom I have been associated. I am sorry that I have not had more opportunity to carry my share as an officer but I have always tried to follow the dictum laid down by J. P. Morgan, true executive ability consists of having others work for you.

While listening to the program and seeing those beautiful movies which depict so clearly many things which cannot possibly be understood unless actually seen, it was brought home to me how far the surgery of trauma has advanced in the past forty years. It is just that long this month since I started in practice and I would like to paint from my own experience a picture of what was going on forty years ago and what has been achieved. I think it is interesting to speculate upon the influences that decisions made in early life have on a man's subsequent career. I remember how I chose the location for my first office. It was two small rooms above a saloon at Root and Halsted streets at the main entrance to the stockyards in Chicago.

At that time I was supposed to be Dr. J. B. Murphy's assistant. No assistant was paid in those days; his apprenticeship with his chief was presumed to more than remunerate him. In fact he sometimes paid for such apprenticeship. In common with most other young doctors in those days, I had had no internship and no residency, and probably was not worth much

anyway. When I decided to open my own office, I discussed the matter with Dr. Murphy who advised locating in the stockyards district. Those of you who know Chicago know what Halsted Street was and is. He said that for one interested in bone and joint surgery the industrial district was the place to obtain experience and he was right. I had a further incentive for wishing to blossom out on my own. I wanted to marry the girl to whom I had been engaged for some time and I thought there would be more prestige in having my own office than in being an assistant, even to John B. Murphy. She was in complete agreement with this. We therefore combed the stockyards district, riding up and down Halsted Street by trolley car until we came to Root and Halsted. There was plenty of activity at that corner and we thought that this was a good place so we looked for a location and finally selected the two rooms over the saloon on which the rental was \$35 a month, which was a lot of money.

I had a vague acquaintance with an official of one of the packing houses and, after waiting in vain for some time for patients to flock to my door, I went over to see him. As a result he gave me a letter of introduction to the president of the Chicago Junction Railway, a switching railroad that handled incoming and outgoing freight from the yards. After some preliminary skirmishing he promised that all calls which could not be taken care of by the company doctor would be referred to me. To him that was

probably just a way of easing me out but to me it meant the God-given opportunity to "strut my stuff" when, as and if patients materialized. And they did materialize. The first patient who came in was Mike McKenney, bless him, and I shall never forget that name. Mike had a fissure fracture of the patella. I knew enough about the knee joint to decide the ligament was intact and he probably would get well if I kept hands off. But it was a fractured patella. It happened that two railway employees had had fractured patellas, one two years and one three years before. Both had been operated upon and were still laid up. I did not operate on my patient but applied adhesive strapping and a posterior splint and turned him loose. He walked from one end of that district to the other telling them what a great man I was. When he got well and was able to return to work in eight weeks or so my reputation was made. The grapevine works well in a self-contained district such as the yards. The other two men were still laid up.

I was still working at Mercy Hospital and, having no secretary, switchboard operator or "receptionist," the problem arose of what to do when calls came to the office and there was nobody to receive them. In those days the saloons were open twenty-four hours a day, with a bartender or two always on duty. I decided to ask my landlord, the saloonkeeper, whether I might have an extension telephone run from the bar to my office. This was agreeable to him and I thought this took care of the situation, in part at least. However, business still had to be drummed up so in odd moments it was necessary to contact the timekeepers in the various plants. These were the key men so far as accidents were concerned and most of them were willing to call me when the company doctor could not be reached. I told them there was twenty-four-hour telephone service at my office and there was. The bartender who took the call would say that I had stepped out for a few moments and to send the patient over. Then he would phone me at Mercy Hospital, about  $1\frac{1}{2}$  miles away, and I would dash out in my little two-cylinder automobile (some of the old-timers may remember them) and take care of the patient.

By such devious means we made a start in industrial bone and joint surgery—possibly unfair competition in cutting in on the practice of the established men in the community. I doubt if such methods would be approved of

today. But we were taking care of injured and sick people; we were hospitalizing many more patients than had been the custom. Any badly injured man was sent to the hospital and given the best care that could be given. This, of course, caused repercussions in the claims departments whose motto in those days was to settle an accident case promptly and as cheaply as possible. There were no Industrial Commissions then and the services of doctors and hospitals were not regarded highly in the minds of those who handled the claims.

The type of surgery performed forty years ago was extremely crude by present standards. So far as I can remember we had no anesthetics except chloroform, ether and nitrous oxide. We had no facilities for transfusions, no intravenous salt or glucose solutions nor any of the other adjuncts we take for granted today. So far as sterile dressings were concerned we were in what Dr. Murphy called the "mason jar" stage of hospital equipment. Practically all the dressings at Wesley Hospital (the University Hospital of Northwestern University) were in baskets filled with mason jars into which dressings of various sizes had been packed and then sterilized; in the corner of the basket was a Kjelland's forceps in a jar of 70 per cent alcohol. But to sterilize the instruments—who ever heard of using sterile instruments for ordinary dressings? We had designed and made what I believe was the first dressing cart used in Wesley Hospital. It worked and was popular so that whenever I needed it, it was in use. In order to reserve it for our own use I covered it with a sheet of iron equipped with a padlock to avoid having to track down Allan Kanavel or Sumner Koch or others I might mention. X-rays were far from adequate. Hollis Potter had not yet designed the Potter-Bucky diaphragm and an x-ray of the spine looked like a snowstorm. At times the outline of the spine could be seen vaguely but in a fat person even that was almost impossible.

Those are a few of the handicaps we had to contend with. The motor-driven bone saw and the other instruments we take as a matter of course were practically unknown in the average hospital. I had designed a motor-driven saw the year I graduated from medical school; Albee's came out about the same time. The saw required careful handling and was tricky but worked well. One of my good friends who had seen me use it asked if he might borrow it for a bone-grafting operation. I loaned it to him and

in the process of getting the graft out the saw whipped around and cut off his interne's finger. So far as I know he has never used a motor-driven bone saw since that day and much prefers to take out the graft with chisels.

When the Red Cross and first aid program started, Dr. H. W. Gentles was the man who instituted the training of teams in first aid care in Chicago in the stockyards and other places. This, I think, was the original effort made by the Red Cross in teaching laymen. Then, about 1914, the compensation laws were enacted in Illinois and for several years they were in operation without having a medical director. Incidentally, these laws were fought tooth and nail by employers as well as by the medical profession. When they were finally passed, it was found necessary to have the services of someone who could interpret the findings before the Industrial Commission. Unfortunately, at that time the type of doctor who went into industrial medicine was dependent many times upon the favor of the claims agent and too often he became the tool of the claims department to the point that industrial medicine as a whole was looked upon with disfavor by the medical profession and the population in general.

One experience I had with the railway company is worth relating. I had a letter from the company returning a bill which I had rendered, a rather steep bill, saying that this should be reduced or they would get another doctor. I went over to see the president of the company, in no sweet frame of mind, in spite of the fact that the money I received from the railway constituted a substantial part of my income. I told him that if I were to cut the bill, it would be an acknowledgment that I had made it too high in the first place and I would not admit that. I also said that if he did not wish to have his injured employees treated in the same way I would treat him if he were injured, he could get another doctor but that the bill was going to be paid. I stalked out but I must have impressed him because the bill was paid. Via the grapevine I learned that the claims department had been instructed not to question my bills in future. This was the beginning of the educational campaign carried on not only by that company but also those elsewhere in Chicago to educate executives in the humanitarian principles of saving life and limb. It was the beginning of the safety campaign which has become nation wide in scope and is now taken for granted.

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The insurance companies came into the picture because they found that safety measures saved money. There were no safety devices on machines. It was long before workmen were required by law to wear goggles when operating grinding machines. There were no rules against kicking over a draw bar with the foot, with the hazard of catching the foot in the machine. In one week I performed seven amputations for one company, which shows the terrific chances these men took. When I became Medical Director for the Illinois State Industrial Commission I thought that I was in a strong position to carry on an educational campaign not only for accident prevention but also for proper care of accident cases. And education was needed. It was disheartening, for example, to see what could happen to a dislocation of the wrist. It might be treated by exercise for several months, exercises which tore the structures of the wrist to the extent that it became necessary to remove the semilunar bone; and when this was done, it might be found several months later that the median nerve had been cut at the time of operation. Fractures of all types were treated abominably prior to 1922 when the Fracture Committee of the American College of Surgeons was formed. This Committee has been largely instrumental in the education of the general practitioner throughout the country.

A coal mining company in southern Illinois asked me to make a survey of their field to see what could be done about improving medical care. I found not a single graduate of a Class A school in the county nor was there a hospital in the county. I cannot remember how many compression fractures of the spine, malunited and ununited fractures, painful wrists and ankles, and poor surgery I saw during the first few weeks I was there. For four years I spent two days every two weeks in that town and sent all the surgery to Chicago. Now they have a pretty good hospital. The mining companies got together and built the hospital and secured a fairly well trained staff. They have decided that it is better to give good medical treatment than to pay what may be assessed against them by the Industrial Commission.

I did not start out with the idea of giving you a learned dissertation and I am sure you will agree that I have not done so. I have merely related some of my own experiences in the evolution of industrial surgery, the surgery of trauma. To some of the younger men in this

group the conditions with which we had to deal forty years ago may seem inconceivable. The progress that has been made in the last fifteen years alone has been astonishing. It is extremely gratifying to one who went through the days when it was considered rather a disgrace to have anything to do with industrial surgery; it smacked of commercialism and, indeed, in the past I have been tagged with that

epithet, commercial doctor. It is particularly gratifying to know that through the efforts of many of our best surgeons the element of commercialism has been largely overcome in industrial surgery and that through education and guidance, through adherence to the principles of the "good doctor" many lives have been saved and many crippling accidents avoided.



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# Original Articles

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## LIVING WITH WHAT'S LEFT\*

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REHABILITATION, like traumatic surgery, is made up of many components. Those interested in traumatic surgery must first have the basic groundwork training in general surgery; they must know orthopedics, industrial problems and the problems of plastic and chest surgery; they must be familiar with the compensation laws, the problems of pensions (not only dollar-wise but the psychological problems) and, above all, they must have a fundamental interest in the patient. The ultimate objective after surgery is done and the stitches are out is: What can this man do with his life?

Rehabilitation is also a program of many facets. In the first place any program of rehabilitation is only as good as the sound medicine that backs it up. This is fundamental. The diagnosis must be accurate and definitive medical and surgical care must be the best. Then comes the problem of training the individual to live with what he has left. The first phase of medical cure is, obviously, prevention; the second phase is definitive medical and surgical care. In our department at New York University and at Bellevue Hospital we talk now about the third phase of medical care, that period between the bed and the job, a period in the past when many patients had been lost. They were not lost because of death but because we had failed to provide them with the opportunities to learn to live and work with what is left; lost because they had been infected with that insidious disease "hospitalitis."

A well planned, total rehabilitation program is just as important to those interested in traumatic surgery as a well equipped operating room. Without either one you cannot do a complete job.

A rehabilitation service in a hospital should function as a service department, just like the laboratory and x-ray, and should start in the medical and surgical wards. With the amputee it should begin, if possible, before the surgery is done; if not, just as soon as the patient is able to participate in a planned physical and psychological program designed "not just to get him out of the hospital but to take him as far as he can go."

The total rehabilitation team consists of, first, the doctor who is trained in this field. A new specialty board has been established in the American Medical Association known as the American Board of Physical Medicine and Rehabilitation. The requirements are as rigid as any of the other boards and the years of special training required are comparable. However, an individual with good, basic training in surgery, orthopedics, medicine or neurology can learn the essential fundamentals of rehabilitation in a year's time in a properly organized hospital training program. Already the Board of Internal Medicine gives credit toward certification for training on such a service as we operate at Bellevue Hospital, and the Council on Medical Education and Hospitals has published standards on such services in a general hospital.

We see prospective candidates for rehabilitation on the request of other services and after consultation if we think that they can be aided by a training program, such a program is started in their own wards. At the appropriate time these patients are transferred to the rehabilitation wards. At this time our service takes over the major responsibility and the referring service acts in a consultative capacity.

After a check on the general diagnostic

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studies the patient must be tested for muscle strength, joint range of motion and in the inherent needs of daily living. In the Rehabilitation and Physical Medicine Service at Bellevue Hospital a check list of ninety-six items is used to determine these factors. They include: first, bed activities such as moving from place to place in bed and the ability to sit erect; second, toilet activities; third, eating and drinking; fourth, the ability to dress and undress such as tying shoe laces, manipulating buttons, zippers and other fasteners and applying and removing braces; fifth, hand activities, for example, winding a watch, striking a match and using various door knobs and latches; sixth, wheel chair activities, getting from bed to wheelchair, wheelchair to bed and in and out of the bathtub; finally, elevation activities which include the needed abilities for walking, climbing and traveling.

At first glance such a test list sounds formidable and time-consuming but in reality the information may be easily obtained by a therapist, nurse, a well trained volunteer or a member of the patient's family. From special check sheets used for charting the activity accomplishments, information is readily available both on the status of the patient at the time of admittance and his progress while undergoing rehabilitation.

The use of such a check list is particularly helpful if personnel are not available to do definitive muscle testing and accurate range of motion determination for the daily activities test can be completed in the hospital, the physician's office or the patient's home. The subsequent training program is designed to teach the patient the various skills and activities which he cannot perform.

In Bellevue Hospital and the Institute of Rehabilitation, after the basic medical work-up and the range of motion, muscle and needs of daily living tests, the physician, in conference with other staff members, prescribes a five hour a day program for the patient. These prescribed activities include training in the ambulation and elevation rooms and the remedial gymnasium, occupational, physical and speech therapy or any other activity which may be helpful in meeting the specific needs of the patient.

In a comprehensive rehabilitation program vocational guidance specialists should also be available for guidance and to do testing in order that the patient may be started on a prevoca-

tional exploratory and work-testing program as soon as it is medically feasible. However, good basic rehabilitation can be carried out with the personnel available in the ordinary general hospital if such a program is properly organized, supervised and prescribed by the physician.

Although in this country we have the finest institutions in the world for definitive medical care and vocational training, outside of the military services and the Veterans Administration there are but a small handful of civilian agencies and organizations equipped to provide for the patient with a physical disability the necessary retraining in physical skills which are a requisite for later vocational training.

The physician in the past has thought too much about the physiological and clinical aspects of the patient's disability. The vocational counselor too frequently has thought only in terms of physical skills which could be utilized vocationally. Between the two, however, there is a wide area through which most physically handicapped persons must go when their definitive medical care is completed but before they are ready to undergo vocational training. In this area lies the physical retraining in skills necessary for the carrying on of the activities inherent in daily living and common to all types of work.

Except in a few isolated instances the physically handicapped person must be retrained to walk and travel, to care for his daily needs, to use normal methods of transportation and ordinary toilet facilities, to apply and remove his own prosthetic devices and to communicate either orally or in writing. These are such simple things that they are frequently overlooked but the personal, vocational and social success of the handicapped person is dependent upon them.

The criteria for discharge from the rehabilitation service is maximum improvement by the patient with regard to training, the vocational objective is not necessarily the Alpha and Omega. If the hemiplegic can be taught ambulation and self-care, he can free a member of his family who can then take on a productive job; or if the patient can be taught self-care and ambulation while still requiring custodial care, the nursing load of the institution can be relieved tremendously.

Rehabilitation is a service tool in the doctor's hands to allow him to provide a program of complete medical care.

It is interesting to see the total problem we are facing. In 1946 accidents were the fourth most important cause of death. Seventy-three of every 100,000 persons met death in this manner in 1945 as compared with the death rate of 321 per 100,000 population for heart disease, 134 for cancer and 86 for cerebral hemorrhage. Although the number of persons killed in accidents was higher by 3 per cent in 1946 than in 1945, the total death rate dropped to 70.8 as a result of the increase in population.

In 1945 the number of working years lost from accidental deaths was 1,750,000, which may be compared with 1,680,000 from heart diseases, 1,110,000 from pneumonia and 1,040,000 from cancer in the same year. In addition to the 99,000 deaths from accidents in 1946, 10,400,000 persons suffered disabling injuries. Of these 370,000 were disabled permanently. The total cost of such deaths and injuries has been estimated by the National Safety Council in its "Accidents Facts 1947 Edition" at nearly \$6,500,000,000. Slightly over \$1,000,000,000 of this sum may be charged to medical expense and the overhead cost of insurance, \$2,500,000,000 to lost wages and the value of lost services, \$1,500,000,000 to property damages, and the rest to production delays caused by occupational disasters.

Although great public attention was attracted by such disasters as the Winecoff Hotel fire in Atlanta in December, 1946, in which 119 persons lost their lives, the tenement disaster in New York City during the same month in which thirty-eight persons were killed and the Burlington Railroad wreck at Naperville, Illinois, which claimed the lives of forty-seven persons, such disasters contributed less than 1½ per cent of the total number of accidental deaths in the nation. These disasters, which are classified as catastrophies when five or more persons are killed, accounted for 1,300 deaths in 1946. This was 400 fewer than the year before and was the lowest number since 1941. Similarly, although commercial airline crashes are reported widely, the 1946 passenger death rate for scheduled airlines to 100,000,000 passenger miles was 1.2, the same as the 1939 rate and the lowest on record. It is not the sensational fires, floods, plane crashes and railroad wrecks that make headlines which account for our great number of fatal and disabling accidents, but the steady stream of highway, industrial and home accidents.

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#### INDUSTRIAL ACCIDENTS

Of the appalling number of disabling accidents, some 90,000 each year occur in industrial plants. Added to these are more than 2,000,000 other workers who suffer temporary disabilities from accidents. The total work lost in industrial accidents in 1947 was 280,000,000 man-days or the equivalent of 1,000,000 men kept out of work continuously for more than a year.

Few of these men who are severely disabled have a chance for rehabilitation and the opportunity to return to productive work. In most cases they are retired on disability compensation, physical and psychological cripples, their earning power reduced to nothing and their buying power reduced 50 per cent, unwilling liabilities to themselves, to their families and to the nation.

Added to this tremendous social waste are the direct costs of more than \$2,600,000,000 a year in wage loss, expenses for medical care, overhead costs of workmen's compensation, damaged equipment and material, production slowdown, and time lost by fellow workers.

Regardless of their occupation, place of injury or type of disability, injured workers in the United States have one thing in common—the benefits of compulsory workmen's compensation insurance. This is of paramount importance in the problems of traumatic surgery.

At first compulsory workmen's compensation insurance was limited to dangerous enterprises. However, with the growth of modern industry and increased use of power-driven machines in factories and transportation, the danger of accidents and occupational diseases multiplied and it is now universally recognized that an employer is liable for injury to a worker arising out of and in the course of employment, regardless of guilt. When the new Workmen's Compensation Law became effective in Mississippi on January 1, 1949, it meant that all forty-eight states, Puerto Rico and the eight provinces of Canada had such laws. Each act is administered locally, for the United States Workmen's Compensation Law, passed in 1908, applies only to cases involving federal jurisdiction.

Common to all states, an integral part of the workmen's compensation system is the problem of medical care, for no claim can be compensable unless there is competent medical evidence to prove the disability was caused or aggravated



by the occupational injury or disease; nor can disability benefits be granted without a medical examination and report. The importance of medicine in compensation is seen by the fact that doctors and hospitals in New York State alone in 1947 received more than \$25,000,000 for services to injured workers in nearly 800,000 reported cases of industrial accidents and disease.

Although medical care has played an increasingly important role in workmen's compensation since the concept of employer liability for injuries to workers was first expressed in Czechoslovakia in 1514 and in the Electorate of Cologne in 1669, the problems of compensation medicine, unfortunately, like those of general medicine, have too frequently been considered purely from the definitive aspect without sufficient regard for rehabilitation, the third phase of medicine, which takes the patient from his bed to the job. In no other phase of medicine, however, does rehabilitation play a more important role. To get the worker back to the job in the shortest possible time, trained to work with what he has left, are the objectives both of rehabilitation and compensation medicine.

Until the advent of World War II, medical care, psychologic problems and the vocational retraining of the disabled worker to the point where he could resume productive work were too frequently considered as separate and distinct processes having little relationship to each other. That they are interdependent and inseparable has been demonstrated by the successful programs in military and veterans' hospitals and has been recognized in civilian rehabilitation by the Barden-LaFollette Amendment which expanded the federal-state vocational rehabilitation programs to include physical restoration, psychiatric services and medical care as well as vocational guidance and training.

Immediately following World War I, as today, there was a developing interest in increasing rehabilitation opportunities for the disabled. Unfortunately, this interest died in most quarters in the years between the wars. However, some pioneer institutions did come from it such as the Institute for the Crippled and Disabled in New York and the Curative Workshop of Milwaukee and Cleveland Rehabilitation Clinic, and some basic legislation such as the Federal Vocational Rehabilitation Act of 1920. The failure of the movement to gain sufficient stature to become an accepted

part of medicine, can be attributed to the fact that it was restricted largely to guidance, trade training and the purely vocational aspects of rehabilitation. Few provisions were made for physical restoration or reducing the physical disabilities of the trainees. When the physical condition became static, a program of vocational rehabilitation was planned, "training around" the disability rather than attempting to reduce or eliminate it through medical procedures. In many instances a comparatively large expenditure of time and money was necessary for vocational rehabilitation when, by the expenditure of a few weeks and a more modest sum, the physical limitations could have been substantially reduced with an automatic increase in employment potentials. Such restrictions made it impossible for the state vocational rehabilitation program operating under the Federal Office of Vocational Rehabilitation to give adequate service to their clients. Such failure is shown by the fact that until the basic philosophy of this program was changed by the Barden-LaFollette Act of 1943, in twenty-three years only 210,000 persons were rehabilitated although over a million persons were in need of such aid at any given time during that period.

Rehabilitation under the federal-state vocational rehabilitation programs reached an all-time high in 1948 when 53,131 disabled persons were given services. This represented an increase of 21 per cent or 9,000 clients over the preceding year. Amputations or congenital absence of members constituted the disabilities of 7,276 of the 1948 rehabilitants. Persons with other impairments of limbs as a result of injury or disease numbered 17,042.

Although an increasing number of referrals to the state rehabilitations are coming from physicians, it is ironic that they still constitute only 23.3 per cent of all referrals. Significantly, only 8.9 per cent of all referrals are made from state workmen's compensation agencies and other insurance groups.

Last year the average case cost to state rehabilitation agencies was \$460 or approximately the same amount it costs to maintain a person in dependency for one year. Before rehabilitation about 45 per cent of the group were dependent upon their families for support, 8 per cent lived on their insurance benefits, about 8 per cent received public assistance and only 29 per cent were living on their wage earnings.

Since the federal-state vocational rehabilita-

tion program was broadened to include medical services in 1943, 219,039 disabled men and women have been rehabilitated as compared with a total of 210,125 for the preceding twenty-three years. These 219,039 disabled persons have already increased their earnings and the nation's purchasing power by more than \$900,000,000. At the same time these persons have since their rehabilitation paid upwards of \$67,000,000 into the federal treasury in federal income taxes alone.

Dealing with the specific, the amputee offers a good example that the surgeon must not only do an amputation that is technically sound but also assume the responsibility for preparing his patient physically and psychologically for the amputation and see that the patient has the proper prosthetic device and is trained in its use.

One phase of the management of the amputee to which the traumatic surgeon should give particular attention is the immediate post-operative period while the stump is being shrunk in preparation for a prosthetic device. During this period of six to eight weeks the patient should be given graduated conditioning exercises in preparation for both crutch walking and the later use of the artificial limb. Also, measures should be taken to prevent anatomic deformities. For example, it is not an uncommon practice in many hospitals following an above-knee amputation to elevate the stump upon a pillow. However, if such elevation is maintained for as long as two weeks, a flexion deformity will occur which will take from six to eight weeks of arduous, painful work before sufficient hyperextension can be regained for satisfactory walking.

In advising his patient on the selection of a

prosthetic device the physician must be aware of the fact that not all limbs are suitable for all amputees. In fact, he must realize that not all amputees can wear artificial limbs profitably. It has been noted on the rehabilitation service at the New York University College of Medicine that an above-knee amputee in the older age group cannot as a rule be trained profitably to use a prosthesis if he is unable to perform a swing-through gait on crutches.

The physician must point out objectively to the patient those skills which the patient can expect to achieve with proper training and those skills which the patient has little chance of ever regaining. Extreme caution must be taken in the latter, however, as it is unwise to tell a patient what "he cannot do" for this cannot be determined in most cases until the patient has had adequate training. Training is absolutely essential if the amputee is to be successfully rehabilitated.

Regardless of the type of disability the responsibility of the physician to his patient cannot end when the acute injury has been cared for. It ends only when the physician has taken the responsibility for seeing that proper referral has been made to those agencies and institutions which are equipped to rehabilitate and retrain the patient with a residual physical disability. The doctor who fails to see that those patients under his care receive the full benefit of modern methods of medical rehabilitation and retraining is in the same category as the physician who still persists in using dietary restriction alone in the management of diabetes when insulin is available, for medical care is not complete until the patient has been trained to live and work with what he has left.



# OSTEO-ARTHRITIS AGGRAVATED BY TRAUMA

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THERE is probably no problem more vexing to industrial surgeons than that concerning the relationship of osteo-arthritis and trauma. It is generally recognized that persons with osteo-arthritis following injury, often of a minor nature, may have undue prolongation of symptoms. However, there is very little in the literature concerning the prevalence of this condition and not much of significance has been written concerning the role in industrial disability of osteo-arthritis that has been aggravated by trauma.

In order to investigate this problem we have, in addition to reviewing the literature, summarized and analyzed eighty-five patients that have been seen by us in the past eight years. An attempt has been made to include in this group only those individuals who have had osteo-arthritis as the cause for prolongation of symptoms. Excluded from the group were those patients who had obvious septic, psychotic or metabolic factors. We have excluded in this analysis those sustaining a fracture, although even in these individuals after a fracture, it is our clinical impression that symptoms may be somewhat prolonged. Thus in this group of eighty-five patients there were only two obvious etiologic factors: trauma and osteo-arthritis. We well realize that this represents a clinical and not pathologic selection for tissue studies are not frequently performed. For obvious reasons no control was possible in this study. We have reviewed the sex, age and occupation of these patients. The mechanism of the injury, part or parts involved, type of therapy employed, ultimate end result, when it could be ascertained, and the degree of permanency have been analyzed. The role of litigation in this group has been determined and, in most instances, we have been able to ascertain the financial involvement. The time lost from work and the number of patients requiring hospitalization have been investigated. We have not excluded any cases in this review of our files of private patients over an eight year period except for the reason that data were very incomplete or the patient was not representative

of the problem in question. We are indebted to a number of insurance carriers as well as to many patients for their cooperation in this report.

We have been interested in various aspects of this problem and in analyzing our patients sought to clarify the following questions:

1. What were the usual mechanisms of injury producing this clinical condition?
2. What was the duration of symptoms before these patients were seen?
3. How many were industrial patients?
4. How many had previous symptoms of arthritis?
5. How many required hospitalization?
6. How much time was lost from work as a result of injury superimposed on osteo-arthritis?
7. How many had radiographic evidence of arteriosclerosis?
8. What was the role of body type?
9. What was the financial involvement in the management of these patients?
10. How many were considered clinically cured after treatment?
11. May death result from injury in an osteo-arthritis without the presence of a major fracture?
12. What is the prognosis in an osteo-arthritis who has had an injury?
13. What treatment seemed to be effectual in the management of this syndrome? What has been the scope of therapy?
14. Is an osteo-arthritis that has been aggravated by trauma different from traumatic arthritis?
15. Is the industrial worker of fifty years of age and over an economic liability because of the probable existence of osteo-arthritis which may be aggravated by potential injuries?
16. Is there a common pattern of symptoms and physical findings in patients with osteo-arthritis who have prolonged disability after trauma?
17. Are compensation boards justified in recommending a prolonged financial coverage of patients with osteo-arthritis who have

received injuries and in whom symptoms are prolonged?

In our review of the literature we have found relatively little information on this subject. We have been unable to discover any article in which osteo-arthritis aggravated by trauma has been considered as a clinical entity. However, some years ago Allard<sup>2</sup> in a very stimulating and provocative article reviewed the subject of spinal arthritis in its relationship to industrial disability. He stated that since it was impossible to secure statistical evidence of the part that arthritis plays in this type of disability, one must be satisfied with the presumptive evidence of general opinion. That feeling is still pertinent in the twenty years that have elapsed since his report appeared. He quoted various surgeons who were polled at that time on the relationship of low-back pain to arthritis following injury and recorded the following comments:

"1. Industrial types of back complaints over 3 months' duration, in the absence of fracture, showed in 80 per cent hypertrophic arthritis.

"2. The chronicity of the majority of back injuries is due to the already existing or provoked spinal arthritis.

"3. Arthritis is a highly important factor in disabilities of spine origin.

"4. Nearly 100 per cent of men past middle age who sustained injuries to the spine have some element of arthritis present which greatly prolongs convalescence and places them on the pension roll."

It is to be recalled that these opinions were expressed before recognition of the herniated disc syndrome. One of the industrial commissions that was approached by Allard at that time on this subject replied: "The outstanding feature is that men with arthritis invariably suffer longer disability than those who do not show evidence of disease." That statement is a typical one to be found in various writings.

The conclusions of Allard's studies may well be reviewed and summarized as follows: (1) Arthritis in its various types is a common affliction of adults especially the laborer. (2) Extensive arthritis of the spine (and other joints) may be found without symptoms. (3) Symptomatic arthritis in its incipency is without roentgen evidence. (4) Arthritic subjects are prone to disability of greater or less duration from injuries that would not affect a normal person. (5) Disability complicated by

arthritis occasions a longer convalescence than disability occurring in normal spines. (6) A victim of arthritis is not a normal man. His efficiency is lowered. He is awkward, often distracted by his discomforts, easily fatigued and an easy prey to minor accidents. He is an industrial hazard. (7) Patients with recognized arthritis, properly advised, may be preserved for years of usefulness with big savings to industrial insurance.

Mercer<sup>11</sup> states that the influence of trauma in osteo-arthritis is not sufficiently appreciated. He recalls that all writers are agreed as to the importance of trauma in osteo-arthritis and points out that the injury may be a continuous, chronic, occupational strain or sudden and severe and may have caused a fracture near the affected joint. Injury will serve to determine the onset of arthritis in joints of individuals who have already suffered slightly from generalized arthritis. For example, an injury to a knee or hip is likely to precipitate a troublesome form of arthritis in the injured joint. For this reason, joint injuries in arthritic persons assume an unusual importance and should be prevented or efficiently cared for. While prevention is the first thought, however, the question of how to prevent development of the condition of uncertain etiology, insidious onset and chronic progression is at present beyond solution. The conditions can be treated only as they are found.<sup>2</sup> In considering this problem one must also realize that other factors may play a part in the development and persistence of symptoms. The psychotic personality, postural errors and numerous constitutional causes, such as sepsis, metabolic disorders and, much less frequently, malignant changes must all be considered.

We believe the middle-aged or elderly person who sustains joint injury with prolonged disability in the absence of other definite findings must be considered as having an osteo-arthritis even if the radiographs are normal. Additional x-ray studies after several months may show definite early changes to confirm the clinical impression. This is particularly true in back injuries. Ghormley<sup>4</sup> has pointed out that some types of backache cannot be properly tabulated in any group early in the course of treatment and noted that exact diagnosis might have to await development of definitive radiographic changes.

All are familiar with patients in whom a

joint becomes acutely painful, swollen and red following an injury, and in whom the underlying etiologic factor is a metabolic disorder. In such instances the administration of colchicine and a low purine diet will usually eliminate and control symptoms. Examples of such cases are not included in patients to be presented as these do not truly represent osteo-arthritis aggravated by injury.

Numerous authors have also pointed out that sepsis may cause prolongation of symptoms after injury; and in all patients with an osteo-arthritis following injury, attention must be directed to the elimination of any septic foci—particularly in the teeth, prostate and gastrointestinal tract. Too often the mild alleged etiologic factor is only an incident while the true cause may be hidden in some constitutional or pathologic condition far removed in another part of the body. This must be sought and found when the patient first presents himself if true diagnosis and proper management of the case are to be logically established.<sup>1</sup> Some of our patients at first considered to be examples of osteo-arthritis aggravated by an injury were found on further study, often after a failure to respond to conservative measures, to have an active focus of infection. Symptoms subside in this type of individual following adequate therapy to the septic factor. We emphasize this point in spite of the efforts of some to minimize the role of foci of infection. We realize that focal infection is not a causative factor in osteo-arthritis. Certainly removal of foci indiscriminately is to be condemned, but a search for focal infection is an accepted procedure in our patients. Congenital anomalies probably play a very small part in the problem as we visualize it.

Arthritis in all of its various manifestations is a common disease of adults. Garvin in a review of about 2,000 radiographs of the spine taken at the Mayo Clinic in subjects over fifty years of age for conditions other than spinal—being mostly of the urinary tract—found that 67 per cent of the men and 40 per cent of the women had hypertrophic arthritis of the spine. The laboring man with spinal arthritis is often in his occupation exposed to danger of accidental disturbance of arthritic adhesions. Often relatively minor accidents such as twists or falls that would not affect the normal spine, produce obstinate disability of varied duration even to permanent incapac-

ity. In osteo-arthritis, hypertrophic bone changes precede the development of symptoms. Very frequently hypertrophic spurs and ridges may reach astonishingly large proportions without producing sufficient disability to cause the patient to discontinue work. Because adaptive adjustments keep pace, distress is thrown on the spine. However, the margin of safety is always reduced. The last-straw factor may break the compensation at any stage in the development of an osteo-arthritic spine.<sup>6</sup> It is well known and should never be overlooked that many individuals have chronic arthritis not only of the spine but of many of the other joints without symptoms. Sooner or later such osteo-arthritic changes will bring on pain and disability regardless of any trauma. An entirely normal motion or stress no greater than has been sustained many times before may become a last-straw factor and pain begins. Industry suffers a severe drain on its manpower from this type of affection since slight trauma may throw on the disabled list for very long periods those whose bodies have been repeatedly insulted by postural errors and the consequent mechanical strain.

The current feeling about the relationship of osteo-arthritis and trauma is that it represents an aggravation of a pre-existing disease by injury and is an industrial injury and not an occupational disease.<sup>5</sup> Of medicolegal interest are some recent decisions handed down which indicate that should disability develop in the worker during the course of his employment even without injury, the case might be considered compensable since the rulings have indicated the effort involved, even though it was not unusual, was at the moment sufficient to constitute an injury. On the basis of these decisions, if upheld, many litigation cases can be anticipated especially if osteo-arthritis is mentioned as a hidden etiologic factor.

One can readily differentiate between rheumatoid arthritis as aggravated by injury and osteo-arthritis aggravated by injury in that in the former the patient has had symptoms prior to development of x-ray changes. In osteo-arthritis well-developed bone lesions are usually apparent before symptoms arise. In rheumatoid arthritis pain practically always precedes development of visible bone changes; in addition, physical stigmata of rheumatoid arthritis are quite characteristic.

In an interesting discussion of trauma and

disease some years ago Moorehead<sup>7</sup> completely ignored the subject of osteo-arthritis in its relationship to trauma. He pointed out that trauma and disease may coexist. He stated that trauma cannot cause disease as a sole factor but that trauma can activate disease. He pointed out that patients can have well advanced disease and be wholly unaware of it, and in this respect his comment is pertinent to the aggravation of osteo-arthritis by injuries.

Lewin<sup>8</sup> has noted that one must differentiate between traumatic arthritis of the spine from trauma to an arthritic spine and trauma to the spine of an arthritic person. Traumatic arthritis is that form of arthritis usually affecting one joint or one part of the body following an injury in which no changes existed prior to the injury, and in which the radiographs and perhaps even the physical findings at a later stage may resemble those of an osteo-arthritis. Traumatic arthritis is seen often in the younger age group. We have frequently observed traumatic arthritis developing in a joint after an injury with a gradual subsidence of symptoms. Months or years later there may be another traumatic insult to the joint, perhaps mild in degree, following which symptoms may again develop and disability may extend over a prolonged period. Examination after the second injury may reveal clinical and radiographic findings similar to those seen after an osteo-arthritis aggravated by trauma since in both the changes are hypertrophic in nature. A history of the first injury serves to clarify these conditions. Therapy may be similar, however, in both instances. In order to show a casual relation between osteo-arthritis and trauma, there must be definite evidence of time, place and degree.

In order that the physician can differentiate between a true primary traumatic arthritis from a non-traumatic arthritis affecting a joint subjected to repeated trauma, certain criteria have been laid down by Morrow.<sup>13</sup> These criteria are important in view of the frequency with which persons seek compensation for alleged traumatic arthritis. They are as follows: (1) The trauma of a specified accident must be severe enough to produce acute inflammation (synovitis) of the affected joint, pain, swelling, effusion and dysfunction. (2) The traumatized joint must be the only one showing such inflammation. (3) It should be established that prior to the alleged injury articular func-

tion was normal, but the patient's statement to that effect does not constitute proof thereof. (4) Progressive articular changes may occur and in time be demonstrable clinically and radiographically. These changes should appear within a reasonable limit of time, sometimes within six weeks, generally, within three to six months. When posttraumatic intra-articular osseous changes do occur, they are usually hypertrophic in nature resembling those of an ordinary osteo-arthritis.

Hench<sup>14</sup> has emphasized that lesions produced by acute trauma may be varied. These should not be thoughtlessly lumped under a single term "traumatic arthritis." Ligaments or capsules may be stretched, lacerated or ruptured. Synovial membrane may escape injury or traumatic synovitis develop. Menisci may be displaced, detached, split or torn. Articular cartilage may escape damage or be compressed, split or detached from subchondral bone. Juxta-articular bursae may be the main or only site of trauma. In severe injuries, joints may be dislocated or bones fractured. If one would consider the knee joint, the patient may state that symptoms had developed after a fall on the knee six months previously. Radiographs may show mild, moderately advanced or severe osteo-arthritic changes. Clinically, however, one may readily demonstrate various pathologic components. If fluid is present, there is a synovitis. If the significant physical finding is tenderness over the inner tibial plateau, one is dealing most likely with tibial bursitis as described by Voshell.<sup>23</sup> If a fine crepitation is demonstrated, limited to the patello-femoral compartment especially when flexion and extension are executed with the hip at ninety degrees flexion with the abdomen, one is most likely confronted with a traumatic degenerative fibrillation of the patella. If locking episodes are present, associated with localized tenderness over the joint fissures, meniscus injury is to be considered. Thus although the radiographic diagnosis is an osteo-arthritis the clinical diagnosis may be more exact. In inaccessible joints, particularly in the spine, such careful interpretation of physical findings is not possible.

A few pertinent facts related to posttraumatic osteo-arthritis have been recorded by various writers. Usually there have been pre-existing degenerative changes in cartilage associated with acute trauma. Pathologically there are mechanical changes in the joint, altered weight-

bearing lines and edema of the soft tissues of the joint. The symptoms consist of pain that is aggravated by activity and physical signs include local tenderness, swelling and limitation of motion. Most frequently the knee and lumbar spine are affected. The hip, shoulder, thoracic and cervical spine are next in frequency. Usually this condition is seen in those over forty years of age and is more common in males. It has been stated that the onset in 50 per cent of the patients is sudden after an injury; while in the other 50 per cent, it is gradual after an injury.

In discussing the relationship of trauma to various chronic degenerative diseases the word trauma is employed in a special and definitive sense to mean a sudden, mechanical, external violence at a single occurrence, and not to include repeated or ubiquitous, habitual stresses and strains to which the joints of man are subjected at his daily work.<sup>9</sup>

Pearson in 1928 produced evidence that degenerative changes took place in the posterior root fibers as the result of arteriosclerosis affecting the column of Goll, the ability to perceive vibratory stimuli being thus diminished. It was suggested that the influence of arteriosclerosis in osteo-arthritis is exerted in this way and not directly in the blood supply to the joint which Keefer and Meyers have shown is not affected in proportion to the severity of arthritic changes.<sup>12</sup>

Mechanical injuries frequently elicit neuro-circulatory disturbances which are local rather than systemic. The remarkable sensitivity of vasomotor mechanism to local stimuli has long been known. Leriche and his collaborators have been particularly concerned with local reflex vascular reactions to injury. They believe that mechanical stimulation of peripheral nerves may result in the establishment of a state of vasomotor disequilibrium. Occasionally and for no apparent reason a vasomotor disturbance apparently initiated by trauma may persist for a considerable period of time either in the form of a spasm or dilation. The potential importance of neurogenic circulatory disorders, especially following trauma, cannot be denied; but until the methods at the disposal of pathologists are greatly improved, pathologic studies will contribute but little toward their recognition or understanding.<sup>18</sup> It has been suggested that when disability develops in osteo-arthritis there has been an aggravation by metabolic

and chemical changes which are taking place and which cannot be described accurately in the light of present knowledge.<sup>9</sup>

In the treatment of osteo-arthritic joints aggravated by trauma in which symptoms have been unduly prolonged we believe that Watkins has eloquently summarized the philosophy of the therapeutic management: "The restoration of compensation or adaptation which has been broken by the last-straw strain may be a long and tedious process. It is an absolute necessity that a program be carefully supervised and intelligently directed in order to permit the re-establishment of an adaptive compensation for the rehabilitation of the worker. The regime aiming at recovery should be as closely supervised and meticulously directed as the "come-back" of a patient with a healing cardiac occlusion or a patient with a healed tuberculosis of the lungs. Rehabilitation for the lower back, for example, so that adaptation and compensation are restored requires time, patience, close supervision and intelligent graduation of selected exercises. No careless instruction to 'go out and do light work' or 'take setting-up exercises' will meet the requirements. The come-back road may be difficult, but success lies at the end. The broad and easy way leads only to failure and disappointment."<sup>6</sup>

It is our belief that when establishment of this syndrome has been recognized, treatment should be based along sound, mechanical lines with the use of principles that have been outlined in many sources for the management of osteo-arthritis. Reassurance is an important preliminary in starting therapy. The patient must be informed that his disability is fundamentally a benign disorder. If coexistent neurotic conflicts and the attendant muscle tension appear to aggravate disability, the resolution of emotional problems and attainment of relaxation may produce striking benefit.<sup>21</sup> Improvement in the general health of the patient, including a loss of weight if obesity exists, is indicated along with the elimination of gravity for a short period of time, particularly in back disability, the development of the musculature on either side of the affected joint by graduated and well outlined exercises, possibly the use of traction, immobilization with exercises, the use of intelligent physical therapy, procaine infiltrations and perhaps even manipulations. The general build and posture of the patient should be considered.

Often in low-back disability attention to footwear, gait, method of standing and walking will often be followed by significant improvement. Many writers have emphasized the importance of the appreciation, explanation and correction of bad body mechanics. "Haphazard mechani-

TABLE I  
OSTEO-ARTHRITIS AGGRAVATED BY TRAUMA

	No.	Per cent
Males.....	61	71.8
Females.....	24	28.2
Age		
30-39 years.....	1	1.2
40-49 years.....	6	7.0
50-59 years.....	36	42.4
60-69 years.....	30	35.3
70-79 years.....	11	12.9
80 years and over.....	1	1.2
Total.....	85	

cal measures and half-hearted medicinal procedures often accomplish very little or no improvement and create discouragement and economic loss on the part of those who are responsible for the care of the patients."<sup>19</sup> The physician may often render invaluable aid

TABLE II  
OCCUPATIONS

	No.
1. Laborer.....	38
2. Housewife.....	19
3. Office clerk.....	8
4. Salesman.....	5
5. Farmer.....	3
6. Truck driver.....	2
7. Retired.....	2
8. Miscellaneous.....	8
Total.....	85

in rehabilitation in these patients by approaching employers directly or through the insurance carrier. We have been impressed in a number of instances with the cooperation on the part of the employer in taking the patient back early, perhaps at light work or on part-time, after he has become acquainted with the cause of disability and scope of therapy.

#### REVIEW OF CASES

**Sex.** In our selected series of eighty-five patients in whom an underlying osteo-arthritis  
*November, 1949*

had been aggravated by trauma males were more commonly afflicted, the ratio being 7:3. While the pathologic reviews in osteo-arthritis have shown the distribution of histologic changes to be nearly equal in the two sexes, clinical manifestations are stated to be more

TABLE III  
DIAGNOSIS

Part Involved	No.	Per cent
1. Cervical spine.....	13	14.3
2. Dorsal spine.....	3	3.3
3. Dorsolumbar spine.....	5	5.5
4. Lumbosacral spine.....	22	24.2
5. Shoulder (acromioclavicular).....	10	10.9
6. Knee.....	19	20.9
7. Ankle.....	5	5.5
8. Mid-tarsal joints.....	6	6.6
9. Hip.....	2	2.2
10. Elbow.....	3	3.3
11. Wrist.....	3	3.3
Total.....	91	

often seen in females than in males. Since injury is the added factor in our study, it can be readily understood that males would be more often affected especially in an industrial area.

**Age.** Two-thirds of all patients in this series were between fifty to seventy years of age. (Table I.)

**Occupation.** The occupations of these eighty-five patients are tabulated in Table II. Correlation of the scene of injury with the patients' occupations showed that in forty-four patients (52.3 per cent) the occupation was associated with the onset of disability.

**Site of Disability.** The joint or region that was injured is tabulated in Table III. In five patients more than one part of the body was traumatized and therefore ninety-one different sites were noted involved in eighty-five patients. If the cervical spine is included, we found that disability in this group for the spine was 47.3 per cent. The knee joint was involved second in frequency to the spine (20.9 per cent).

**Length of Disability.** The length of disability or the period of time that disability had existed prior to the first examination by us is indicated in Table IV. In one-half of the cases studied the injury inaugurating disability had occurred three months or longer before and in one case had extended back eighteen years. Certainly nowhere in the field of trauma does



one find such prolonged disability often out of proportion to extent of the injury. This is especially true when it is recalled that in this series fractures, dislocations, subluxations, sprains, ligament or tendon ruptures and meniscus displacements were not included. If

TABLE IV  
LENGTH OF DISABILITY BEFORE EXAMINATION  
(Average: 53.8 weeks)

	No.
1-7 days.....	13
1-2 weeks.....	5
2-4 weeks.....	9
1-3 months.....	15
3-6 months.....	19
6-12 months.....	11
1-18 years.....	13
Total.....	85

this group is analyzed from the consideration of existing disability prior to examination as being under or over three months, it is found that forty-two patients had symptoms three months or less, the average being 35 weeks. Those whose disability had existed longer than

TABLE V  
BODY TYPE AND OBESITY

	No.	Per cent
Type:		
1. Asthenic.....	80	95.3
2. Sthenic.....	4	
3. Not stated.....	1	
Total.....	85	
Obesity:		
1. No.....	30	61.2
2. Yes.....	52	
3. Not stated.....	3	
Total.....	85	

three months, forty-three patients comprising this group, were found to have had an average disability of 2 years.

*Body Type and Obesity.* Among the contributory factors in the causation of osteo-arthritis, obesity and malposture are stressed. Of all patients in this group, 95.3 per cent were considered to be asthenic in the sense that body mechanics were considered inadequate. Fifty-two patients (61.2 per cent) were obese. These findings were anticipated (Table v)

*Previous Similar Trouble.* We were interested in the determination of previous similar

trouble prior to the stated injury. In approximately one out of five patients (18.8 per cent) there was a record of the patient having had some previous trouble with the involved joint. In most instances the patient minimized the severity and duration of symptoms in the past

TABLE VI  
PREVIOUS SIMILAR TROUBLE

	No.	Per cent
Yes.....	16	18.8
No.....	63	74.1
Not stated.....	6	7.1
Arteriosclerosis		
Yes.....	9	10.7
No.....	76	89.3

indicating that present disability was unique for the intensity and prolongation of disability. (Table vi.)

*Arteriosclerosis.* Arteriosclerotic changes on radiographic studies were noted in 10.7 per cent of these patients which is probably no

TABLE VII  
MECHANISM OF INJURY

	No.	Per cent
1. Automobile injuries.....	18	21.2
2. Falls.....	38	44.7
3. Struck by heavy object.....	5	5.9
4. Lifting heavy objects.....	12	14.1
5. Miscellaneous.....	12	14.1
Total.....	85	

higher than might be expected in an unselected group of the same age period. (Table vi.)

*Mechanism of Injury.* These have been tabulated rather generally as noted in Table vii but it is interesting to observe that over one out of five patients (21.2 per cent) had disability commence as the result of an automobile injury. The number of falls (44.7 per cent) is in keeping with findings reported by other writers who have studied the subject of injuries. One of us (C. R. H.) has reported a study of injuries in childhood in which the chief mechanism of injury in non-fatal accidents was a fall of 32.8 per cent in all patients.

An attempt was made to indicate the intensity of the injury in these patients but it was believed that any division into mild, moderate or severe would be purely arbitrary and not significant. However, in sixteen patients (18.8 per cent) the injury as described by the patient

TABLE VIII  
NUMBER HOSPITALIZED

	No.	Per cent
Yes.....	39	45.9
No.....	45	52.9
Not stated.....	1	1.2

Total number of hospital days for those admitted: 412  
(Average number of days: 10.6)  
Hospitalization extended from 1 to 31 days

or recorded in the history was considered to be severe.

*Hospitalization.* Of these patients 45.9 per cent were hospitalized for treatment. (Table VIII.) The hospital stay was relatively short, averaging 10.6 days. All hospital charts were reviewed and the laboratory studies revealed almost consistently negative or normal findings except for radiographic reports. In many instances it was noted that the patient on his discharge was still having pain. In only a few instances were complete laboratory studies obtained. In correlating the radiographic findings with the physical signs an attempt was made to classify the extent of arthritis in this series. This was difficult because complete x-ray studies were rarely obtained, the affected part only being examined. In general, chiefly on the basis of radiographic studies, it was believed that the osteo-arthritic changes were minimal in twenty-eight cases, moderate in thirty-one and advanced in twenty-six.

*Time Lost From Work.* The time lost from work after injury in an osteo-arthritic has always been a matter of conjecture. Many insurance carriers find it difficult to accept prolonged disability coverage in patients who sustain a minor injury, especially when they are informed that the radiographs show no fracture about the joint. "Minor arthritic changes" is often the radiographic report of these patients. Table IX is an attempt to show that a great number of patients may be incapacitated for a long period of time after what has been at first considered a minor or negli-

gible injury. Over three months' time from work was lost by 38.8 per cent and 10.6 per cent were not back at work one or more years after the injury. In the fifteen patients (17.6 per cent) who lost no time from work, seven were cases involving litigation. A further break-

TABLE IX  
TIME LOST FROM WORK  
(Average: 30.8 weeks)

	No.	Per cent
None.....	15	17.7
Less than 1 week.....	1	
1-2 weeks.....	6	
2-4 weeks.....	13	
1-3 months.....	13	
3-6 months.....	14	
6-12 months.....	10	
1-2 years.....	3	
2-3 years.....	3	
Over 3 years.....	3	
Not stated.....	4	
Total.....	85	

down in time lost from work dividing the patients into two groups, those under three months or over three months showed that thirty-one patients lost more than three

TABLE X  
TREATMENTS

	No.	Per cent
1. Physical therapy.....	50	58.9
2. Appliances (corset, brace, cast, boots, shoes, arches).....	41	48.2
3. Medication.....	33	38.8
4. Procaine infiltrations.....	27	31.8
5. Bed rest.....	19	22.4
6. Osteopathic or chiropractic.....	11	13.0
7. Surgical:	10	11.8
Manipulation—8		
Other —2		
8. Traction.....	10	11.8
9. Not stated or none.....	5	5.9
10. Deep therapy.....	1	1.2

months, averaging 57.8 weeks. The average time lost under three months in thirty-five patients was 4.1 weeks.

*Treatment.* Treatments employed in this group of patients are outlined in Table X. Physical therapy in one form or another was employed in fifty patients (58.8 per cent) and

actually was probably used by a still greater number. In many patients a great variety of remedies was employed and it was observed that the greater the prolongation of disability, the more varied the therapy. The use of bed rest for nineteen patients, chiefly with spine

TABLE XI

	No.	Per cent
Compensation.....	27	31.7
Liability.....	21	24.7
No litigation.....	37	43.6
Total.....	85	100.00

involvement, is in keeping with the thought that elimination of gravity for a period of time, especially if associated with the use of exercises in the prone and supine position, may hasten convalescence. We have found repeatedly that elimination of the influence of gravity in patients with osteo-arthritis of the spine aggravated by trauma is the most important single weapon in the therapeutic approach to this problem. Often pain and stiffness will increase in the first forty-eight hours of complete bed rest, but following this there is a definite cessation of symptoms in most cases to the point that after one week to ten days all symptoms may subside. This occurs usually without the use of physical therapy.

To prevent a recurrence of symptoms when ambulation is permitted, in certain instances plaster immobilization of the trunk is carried out for four to six weeks during which time Bohler's exercises are stressed. Usually by the end of the sixth week such patients do not require further support although a reinforced lumbosacral corset may be advised for an additional three months.

Early ambulation has no place in patients with osteo-arthritis of the spine following an injury that does not produce fractures. This program of bed rest, however, definitely does not involve inactivity. Patients are encouraged and urged to move about in bed from side to side, but the upright posture in sitting and standing is temporarily eliminated.

Conspicuous by its absence in the list of treatments employed is the use of occupational therapy. The profession as yet is apparently not aware of the significant role that occu-

pational therapy plays in rehabilitation of osteo-arthritis. Even the diversional phase of such therapy has a profound and favorable psychologic influence in these patients who often suffer a prolonged convalescence. The knowledge acquired by these patients in their association with others who have a delayed convalescence that their problem is not hopeless and that recovery will follow in a well planned therapeutic program gives a lift to the morale that cannot be secured by short weekly visits to an attending physician. Perhaps the fact that many hospitals do not have well-equipped departments or adequately trained personnel in this field of occupational therapy is a factor in the neglect of the use of this important phase of therapeutics.

Attention is directed to the fact that only two open surgical procedures were performed in our series. In one instance a subtrochanteric osteotomy with fusion of the hip was done with a satisfactory end result as far as the patient was concerned; but because of litigation, this man still has not returned to work two years after operation.

Surgical procedures are more often employed in our hands in treatment of traumatic arthritis than in osteo-arthritis aggravated by trauma.

*Litigation.* An analysis of the role of litigation showed that 56.4 per cent of the patients in this series were either compensation or liability patients. In 43.6 per cent no litigation was involved. (Table XI.)

We were interested in the percentage of patients in each group who were cured, improved or unimproved following treatment. In Table XII a breakdown of these factors is shown. We believe that it is significant that 96 per cent of all compensation patients were either cured or improved. This would indicate that medical supervision of compensation patients in the State of Pennsylvania is adequate. Since we know that disability often extends beyond sixty days, which is the time period designated by the compensation law for medical treatment, it would appear that the insurance carriers accept responsibility of medical supervision in instances of osteo-arthritis aggravated by trauma beyond sixty days. (Table XII.)

The history of previous similar trouble in compensation, liability and non-litigation was investigated; and as shown in Table XIII only 12.5 per cent of patients in whom litigation was involved stated that there had been some pain

or disability in the affected part prior to the present injury. On the other hand 27 per cent of patients in whom no litigation was involved stated that they had previous similar trouble.

While the numbers involved in this analysis are small, it might well be that compensation

TABLE XII  
LIABILITY, COMPENSATION AND NON-LITIGATION

	No.	Per cent
Liability		
Cured.....	5	23.8
Improved.....	9	42.8
Unimproved.....	4	19.1
Not known.....	3	14.3
Compensation		
Cured.....	20	74.0
Improved.....	6	22.0
Unimproved.....	1	4.0
Non-litigation		
Cured.....	18	48.7
Improved.....	17	45.9
Unimproved.....	1	2.7
Died.....	1	2.7

TABLE XIII  
PREVIOUS SIMILAR TROUBLE  
(Yes)

2 (of 27) Compensation.....	2 Cured
4 (of 21) Liability.....	2 Improved
	2 Unimproved
(Compensation + liability = 12.5%)	
10 (of 37) Non-litigation.....	5 Cured
	4 Improved
	1 Unimproved
(Non-litigation = 27%)	

and liability patients would hesitate mentioning the presence of previous disability for fear of jeopardizing financial coverage of their present illness.

**End Results.** An analysis of our end results showed that forty-three patients (50.6 per cent) were cured. (Table xiv.) In these instances such patients denied any persisting or recurrent symptoms. Thirty-two additional patients (37.6 per cent) considered themselves improved, in many instances considerably so. A number of these patients in another six months or one year would undoubtedly be considered cured. In any event our follow-up examinations indicate that seventy-five (88.2 per cent) of these patients are cured or improved. The one death in the series involved a fifty-nine year old laborer who fell down a flight of stairs at home

two days prior to his hospital admission. He was paralyzed below the cervical spine. Radiographic studies showed no fracture or dislocation but did disclose extensive osteo-arthritic changes. He died twenty days after his injury. An autopsy was obtained and the cervical

TABLE XIV  
END RESULTS AND REHABILITATION

	No.	Per cent
End Results		
Cured.....	43	50.6
Improved.....	32	37.6
Unimproved.....	6	7.1
Unknown.....	3	3.5
Died.....	1	1.2
Total.....	85	
Rehabilitated		
Complete.....	58	68.2
Incomplete.....	10	11.8
None.....	11	12.8
Not stated.....	6	7.1
Total.....	85	

spinal cord found grossly normal. This case was considered typical of a hyperextension injury in the cervical spine without fracture or dislocation, the rigidity of the spine secondary to the osteo-arthritis playing a major role in the final outcome.<sup>20</sup>

**Degree of Rehabilitation.** Fifty-eight (68.2 per cent) of these patients were completely rehabilitated after their injury while an additional ten patients (11.8 per cent) were partly rehabilitated. (Table xiv.) Some patients with residual symptoms classified as improved were able to return to their former occupation. Included in those partially or incompletely rehabilitated were those who stated they miss an occasional day from work or those who had changed their type of work. Among the eleven patients (12.6 per cent) who were not rehabilitated we found three inactive because of litigation; but in each of these patients light work, if available, could have been permitted. Five patients never returned to work because of general debility attendant with their age; one patient had no symptoms referable to her spinal arthritis, but could not work because of a malignant hypertension. One patient was not rehabilitated because of inadequate treatment. The eleventh patient died as noted previously.

*Financial Involvement.* We were able in 93 per cent of these patients to determine the monetary loss as the result of the injury which inaugurated disability. (Table xv.) It cost \$52,390.08 to treat 93 per cent of these people. In one liability case involvement was extremely

TABLE XV  
FINANCIAL INVOLVEMENT IN THIS SERIES  
(Follow-up—93%)

Compensation.....	\$16,476.43
Liability.....	\$17,209.56
No litigation.....	\$18,704.09
Total.....	\$52,390.08

high; but, unfortunately in this instance, the insurance company did not feel free to disclose the amount of money. The monetary involvement in this group varied from \$12.00 to \$8,021.00.

Certainly it cannot be denied that from an economic standpoint the responsibility involved in the management of these patients is high.

*Vehicle Injuries.* We have analyzed those patients whose disability started as a result of automobile injuries. In eighteen patients studied eleven had involvement of the spine following an automobile accident. (Table xvi.)

In 61.1 per cent disability following an automobile accident lasted three months or longer. Litigation was involved in seventeen out of eighteen patients analyzed.

The end result and number of patients rehabilitated are shown in Table xvi. Of these patients 61.1 per cent required hospitalization averaging 9.6 days in the hospital.

In fourteen patients who missed time from work as a result of the automobile accident it was found that the lost time period averaged nineteen weeks. The heavy financial involvement of this group, amounting to \$16,243.56 for eighteen patients, would indicate that the economic importance of automobile injuries in those of fifty years of age and over may be very substantial. (Table xvi.)

We have reviewed records from the standpoint of the part of body involved. (Tables xvii to xx.) It will be noted that patients with osteo-arthritis of the cervical spine averaged fifty-two weeks in time lost from work, whereas patients with osteo-arthritis of the dorsal and/or lumbar spine averaged 27.2 weeks in time lost from work. Knee involvement in this study showed an average lost time of only 15.6 weeks while shoulder injuries lost on an average

of 18 weeks from work. In injuries to the cervical spine every patient was a lost time accident. (Table xix.) It was of interest to note that when litigation is involved it costs substantially more to rehabilitate persons with osteo-arthritis who had sustained an injury. This would be readily

TABLE XVI  
AUTOMOBILE INJURIES

	No.	Per cent
1. Site of Body Involved:		
Cervical spine.....	6	33.3
Dorsal and lumbar spine.....	5	27.7
Shoulder.....	2	11.1
Knee.....	3	16.7
Elbow.....	1	5.6
Ankle.....	1	5.6
2. Length of Disability:		
1-7 days.....	1	
1-2 weeks.....	2	
2-4 weeks.....	2	
1-3 months.....	2	
3-6 months.....	7	
6-12 months.....	1	
Over 1 year.....	3	
3. Litigation: Yes.....	16	88.8
Compensation.....	1	5.6
No.....	1	5.6
4. End Result:		
Cured.....	6	33.3
Improved.....	7	38.9
Unimproved.....	2	11.1
Unknown.....	3	16.7
5. Rehabilitated:		
Complete.....	9	50.0
Incomplete.....	5	27.8
Unknown.....	4	22.2
6. Hospitalized: Yes.....	11	61.1
No.....	7	38.9
(106 days, for average of 9.6 days)		
7. Time Lost from Work:		
None.....	2	
Unknown.....	2	
Yes (1 week to 28 months).....	14	
Average = 19 weeks		
8. Financial:		
Group —\$16,243.56		
Average— \$1,082.00		
(The amount varied from \$80 to \$3,280)		

accepted by anyone interested in this field but we had been able to demonstrate how much more the financial involvement was in breaking down the patients in this series into small groups. For example, it cost \$346.70 on an average to rehabilitate a person with osteo-arthritis of the knee for the group but this amount increased to \$506.74 when the case was one of compensation or liability. In the

shoulder region the cost of improving or curing the patient was \$335.83, whereas in the compensation or liability cases with shoulder involvement the amount averaged \$502.93. In the cervical spine \$1,151.08 was the average for the group; but it cost roughly \$250 more to

4. The mechanism of injury in this type of case showed "falls" to be responsible in 44.7 per cent of the patients, automobile injuries in 21.2 per cent, lifting heavy objects in 14.1 per cent and direct blows by heavy objects in 5.9 per cent.

TABLE XVII  
KNEE INJURIES

	No.	Per cent
1. Litigation: Yes.....	13	68.4
No.....	6	31.6
2. End Results:		
Cured.....	10	52.6
Improved.....	7	36.8
Unimproved.....	2	10.6
3. Rehabilitated:		
Complete.....	15	78.9
Incomplete.....	3	15.8
Unknown.....	1	5.3
4. Time Lost from Work:		
None.....	3	
Yes.....	16	
Group: 249 weeks		
Average: 15.6 weeks		
Under 1 month—7		
1-28 months—9		
5. Hospitalized: No.....	12	63.3
Yes.....	7	36.7
Average: 8.9 days		
6. Financial Involvement: \$6,587.60		
Average { \$346.70—for the group		
\$506.74—for litigation cases		

TABLE XVIII  
SHOULDER INJURIES

	No.	Per cent
1. Litigation: Yes.....	5	62.5
No.....	3	37.5
2. End Result:		
Cured.....	3	
Improved.....	4	
Not stated.....	1	
3. Rehabilitated:		
Complete.....	5	
Incomplete.....	2	
Not stated.....	1	
4. Time Lost from Work:		
None.....	3	
2 weeks.....	1	
2-3 months.....	2	
11 months.....	1	
Not stated.....	1	
5. Hospitalized: No.....	5	62.5
Yes.....	3	37.5
Average.....		11 days
6. Financial Involvement.....		\$2,686.64
Average { \$335.83—for the group		
\$502.93—for litigation cases		

eliminate disability when litigation was involved (\$1,406.33). In osteo-arthritis of the dorsal and/or lumbar spine the average financial involvement for the group of thirty patients was \$820.54. If patients in whom litigation was involved were considered apart, the amount was found to be \$1,413.25. Thus it can be seen that complete rehabilitation is relatively more expensive in compensation and liability patients as compared to patients in whom no litigation is involved.

#### SUMMARY AND CONCLUSIONS

1. Osteo-arthritis aggravated by trauma should be considered as a distinct clinical syndrome.

2. The literature has been reviewed, attention being directed to the paucity of reports on this subject.

3. An analysis of eighty-five patients with osteo-arthritis who had sustained an injury (major trauma being excluded) is presented.

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5. The average duration of symptoms in these patients before being examined by us was 53.8 weeks.

6. Of the eighty-five patients 56.4 per cent had litigation in the form of compensation or liability claims (31.7 per cent were compensation and 24.7 per cent were liability). Of all the patients 43.6 per cent had no litigation mentioned.

7. It was found that 18.8 per cent of the patients studied had had previous similar trouble prior to the injury which initiated the present disability.

8. Hospitalization was carried out in 45.9 per cent of the patients. The average hospital stay was 10.6 days, varying from one to thirty-one days.

9. The average time lost from work in this group was 30.8 weeks. However, fifteen (17.7 per cent) lost no time from work.

10. Radiographic evidence of arteriosclerosis was noted in only 10.7 per cent of the patients.

Our records did not include references clinically on the presence or absence of arteriosclerosis.

11. It was found that 95.3 per cent were considered to have inadequate body mechanics while 61.2 per cent were obese with gradations from slight to marked.

12. The staggering amount of \$52,390.08 was

TABLE XIX  
CERVICAL SPINE INJURIES

	No.	Per cent
1. Litigation: Yes.....	7	58.3
No.....	5	41.7
2. End Result:		
Cured.....	2	
Improved.....	7	
Unimproved.....	1	
Died.....	1	
Not stated.....	1	
3. Rehabilitated:		
Complete.....	4	
Incomplete.....	3	
None.....	4	
Unknown.....	1	
4. Time Lost from Work:		
Total number of weeks.....	626 weeks	
Average.....	52 weeks	
Under 1 month.....	3	
1-6 months.....	4	
6-12 months.....	1	
1-5 years.....	4	
5. Hospitalized: No.....	4	33.3
Yes.....	8	66.7
Average.....	13 days	
6. Financial Involvement.....	\$11,510.75	
	(2 not stated)	
Average { \$1,151.08—for the group		
{ \$1,406.33—for litigation cases		

involved in the management of these eighty-five patients (93 per cent follow-up).

13. An analysis of the end results showed that 50.6 per cent of these patients were cured, an additional 36.6 per cent considered themselves improved while only 7.1 per cent were unimproved.

14. There was one death in this series (1.2 per cent), the result of a hyperextension injury to the cervical spine in which advanced osteoarthritic changes existed.

15. The prognosis in the osteoarthritic who has sustained an injury is good. A total of 68.2 per cent were completely rehabilitated and an additional 11.8 per cent were partially rehabilitated. Of the eleven patients (12.8 per cent) who were not rehabilitated, it was found that

only one had received inadequate medical treatment.

16. Physical therapy is used in the treatment of most of these patients. Open surgical procedures are rarely performed in our hands. In 22.4 per cent the chief therapy employed was bed rest.

TABLE XX  
SPINE INJURIES

	No.	Per cent
1. Litigation: Yes.....	14	46.7
No.....	16	53.3
2. End Result:		
Cured.....	19	63.3
Improved.....	8	26.7
Unimproved.....	2	6.7
Unknown.....	1	3.3
3. Rehabilitated:		
Complete.....	21	70.0
Incomplete.....	1	3.3
None.....	6	20.0
Unknown.....	2	6.7
4. Time Lost from Work:		
None.....	4	
Not known.....	3	
Yes.....	23	(76.7)
Average: 27.2 weeks		
Varied from 1 week to 4½ years		
5. Hospitalized: No.....	15	50.0
Yes.....	14	46.7
Unknown.....	1	3.3
Average hospital period.....	10.2 days	
6. Financial Involvement:		\$21,334.00
Average { \$820.54—for the group		
{ \$1,413.25—for litigation cases		

17. Attention is again directed to the fact that an osteoarthritic aggravated by trauma is different from traumatic arthritis.

18. Our survey indicates that industrial workers of fifty years of age and over may be economic liabilities in certain instances if their underlying osteoarthritic is aggravated by injury. Since a control was not possible in this study, it is impossible to state what percentage of workers suffered disability and what the involvement is from the standpoint of time lost and economic loss. It is our impression that adequate therapy instituted promptly and supervised throughout convalescence will definitely increase the per cent of rehabilitation and reduce the time lost from work. Therefore the economic loss sustained should be reduced accordingly.

19. We believe compensation boards and insurance carriers are justified in recommending prolonged financial coverage of patients with osteo-arthritis who have sustained an injury since this combination is notorious for prolonged convalescence.

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# INTRA-ARTICULAR LESIONS CAUSED BY FAT PAD HYPERTROPHY

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**B**IBLIOGRAPHIC research is extremely disappointing with regard to the subject of fat pad hypertrophy (Hoffa's disease) and its relationship to internal derangements of the knee. From the year 1905 to the present time little mention is made of this disease in the literature; although some references use the name in their title, in discussion they fail to be very clear as to the nature of the essential lesion and its complications. From the year 1905 to 1948 there have been approximately thirteen papers devoted to this subject, mostly case reports, indicating either the extinct state of the condition or unwillingness on the part of the surgeon to recognize it in the differential diagnosis of internal derangement of the knee. It may be of course that the condition is so widely known and generally accepted that its introduction at this time is not necessary.

This is a controversial subject and some of our colleagues while denying the fat pad any role in knee joint derangement will agree that on many occasions they have performed arthrotomies and not found the torn meniscus listed as the preoperative diagnosis. After inspection of the joint it was closed and for some reason or other the patient was thereafter relieved of his symptoms. The point is that adequate inspection of the knee cannot be made through the usual menisectomy incision without excising the greater part of the fat pad. One cannot see all the intercondylar notch and anterior crucial ligament and certainly one would not be in a position to rule out a "bucket-handle" tear of the lateral meniscus which as we know may at times simulate very closely a medial lesion. These patients got well because they were sustaining intermittent intrusion of tongue-like projections into the working surface of the joint and excision of the fat pad was the answer.

On January 4, 1904, Albert Hoffa presented his paper on "The Influence of Adipose Tissue with Regard to the Pathology of the Knee Joint" in Berlin, after which his name was

associated with enlargement of the subpatellar fat pad and the concomitant synovitis and effusion that so frequently accompany it. This same paper was later read at the Fifty-fifth Annual Meeting of the American Medical Association, September 17, 1904. Originally the first description of disturbance of fatty tissue of the knee was made by Johannes Müller and received the term "Arborescent Lipoma." It was at that time depicted as an exuberant growth of fatty villi sometimes to such an extent that it completely filled the knee joint and caused stretching of the joint capsule. In these early descriptions the lipomas found in the joint varied in size from that of a cherry to a walnut and were generally located on the medial aspect of the knee, with or without a pedicle permitting it to intrude into the working joint surfaces. It was thought that trauma played an important role when elements of the fat pad became impinged. The trauma was responsible for splitting thin synovial layers thus causing escape of subsynovial fatty tissue into the free joint area. Hoffa's first experience with fat pad hypertrophy occurred during an arthrotomy for meniscus detachment. The meniscus was found to be intact and the fat pad to be responsible for the patient's symptoms.

We believe from a study of many microscopic sections of this tissue that fatty hypertrophy is in most instances not a true lipoma but rather an inflammatory hyperplasia. Repeated low-grade traumas will bring it about; and when the thin synovial membrane is ruptured by a single violence or eroded by repeated minor pinchings, the subsynovial fat may exude and thus set the stage for subsequent intrusion and damage to the cartilaginous surfaces. There is nothing to add to the original description of this pad. Its presence is constant in the human knee but its size and contour are not. Like the crucial ligaments it is infra-articular but normally extrasynovial. It is covered by a thin synovial reflection on its inner surface and is attached on the other side to the deeper sur-

face of the patellar tendon. There is no relationship apparent between the size of the fat pad and the amount of general body fat in an individual. The tongue-like projections on the articular side will vary in size and enjoy a considerable range of freedom. (Fig. 1.)

This is a report of fourteen patients with knee joint derangement in which the essential lesion was in the fat pad. The condition varied as follows:

1. *Aborescent Lipoma—Two.* In both cases the amount of fat was great enough to produce severe changes in the articular surface of the patella and underlying femur. In one a patellectomy was necessary and in the other a débridement of the articular cartilaginous surfaces

2. *Anterior Bulge of Hypertrophic Fat—One.* The preoperative diagnosis in this instance was that of ganglion arising from the sheath of the patellar tendon. On inspection of the anterior aspect of the tendon it was found to be normal and was being displaced by a mass beneath it. The tendon was then split longitudinally and the fatty mass exuded. Excision of the greater part of the pad could be accomplished through this exposure.

3. *Femoral Tibial Intrusion of Fat Pad with Cartilaginous Lesions on the Femur or Tibia, or Both—Nine.* These were the patients who had intermittent recurrence of pain, locking and effusion.

4. *Femoral Tibial Intrusion without Any Articular Surface Lesion—Two.* These were the acute cases occurring after torsion violence which could not be distinguished clinically from rupture of the medial meniscus.

Trauma is certainly a factor in the production of this clinical picture although in the case of true aborescent lipoma it probably could not be assigned a role in the production of symptoms. Trauma may be a fall on the knee, sudden jerking or torsion of the knee, producing strangulation of the irregular surfaces between the femur and the tibia. The pain is usually located medially over the joint surface and in acute cases both flexion and extension will be restricted by pain, effusion or hemorrhage. Complete extension will not be obtained even after the acute signs have subsided if a tongue-like projection remains impinged. In older patients quadriceps atrophy will be noted as in many other types of internal derangement. There may be visible swelling in the chronic cases on both

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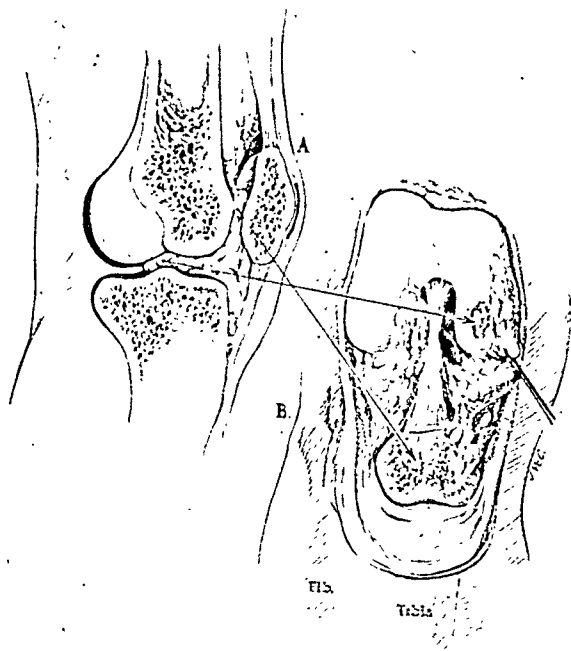


FIG. 1. A, sagittal view of knee showing extension of fat pad between the patella and femur and between the tibia and femur; B, front view showing area of chondromalacia produced by recurrent intrusion of fat pad between articular surfaces.

sides of the patellar ligament. This swelling will be more prominent nearer the insertion of the tendon on the tibia than its origin on the patella. A pseudofluctuance may be created. The tenderness may not be an important sign after acute inflammation has subsided.

When the knee is opened, using the usual meniscotomy incision, the fat pad immediately comes into view. If the joint is inspected before the normal relation of the pad is disturbed by retractors, it will be noted that a tongue-like projection intrudes usually between the femoral condyle and the medial portion of the tibial plateau. In recurring cases this tissue may be flattened, grayish white, firmer than normal and at the point of impingement with the knee in complete extension, signs of erosion will be evident on the femoral condyle. This cartilage will be excavated with some undermining of the edges and frequently radial cracks extending from the center. It will be less glistening and duller in color and a débridement of this area can be accomplished through this approach. In acute cases the offending portion of fat may be hyperemic or dark enough to be considered hemorrhagic or even gangrenous as the case may be.



FIG. 2. Increase in papillary formation of synovial surface of fat pad. The subsynovial fat and connective tissue is the site of chronic inflammatory change with increased fibrosis and chromotropic degeneration.

Following are typical examples of acute and chronic lesions of the fat pad seen in this series:

**CASE I.** L. G., a fifty-five year old white female, 5 feet 4 inches tall, weighing 130 pounds, was admitted to Passavant Memorial Hospital complaining of a painful right knee of three years' duration. The history described an acute onset when the knee "gave way" while she was descending a staircase. No previous trouble with the knee had been experienced. The remainder of the history and general physical examination did not contribute to the diagnosis. On walking she had a definite limp due to inability to straighten the knee completely and her desire to shorten the stance phase of gait as much as possible. There was a slight diffuse effusion throughout the joint and quadriceps bursa but not enough to make the patella ballotable. There was definite tenderness over the medial aspect of the joint surface more anteriorly than laterally. Flexion was limited slightly, probably by effusion of the joint, but extension could not be completed through the final 15 degrees.

Arthrotomy was performed through a meniscectomy incision and a moderate amount of blood-tinged fluid exuded. The synovial membrane covering the fat pad was injected everywhere and a tongue-like projection of fat, golden orange in color, with many small areas of hemorrhage and clots scattered over its surface, was found impinging between the medial femoral condyle and tibia. A sub-total excision of the fat pad was done and the medial and central compartments of the knee investigated. No other abnormality could be found. Her postoperative course was uneventful and she has remained well. (Fig. 2.)

**CASE II.** W. K., a twenty-nine year old white male, 6 feet 2 inches in height, weighing 210 pounds, was admitted to Passavant Memorial Hospital in March, 1947. He told of having injured his left knee twelve years before when he tripped and fell

while running a hurdle race. Apparently the injury was a combination of direct violence to the knee on the hurdle and a torsion violence during the fall. He recovered from the episode without any specific treatment but since that time following slight trauma to the knee it would react by pain, swelling and subsequent disability which he believed was out of all proportion to the violence. Two weeks prior to his admission the above triad of symptoms reappeared following a minor twist and the swelling, pain and locking failed to subside following home treatment of rest, heat and protected weight-bearing.

When examined he had a definite limp due to maintenance of the knee in partial flexion. A moderate effusion was present and tenderness was elicited over the medial margin of the patellar tendon and over the anterior aspect of the joint surface. Flexion was limited to 90 degrees and extension to 160 degrees. Neither the x-rays nor remainder of the history and physical examination were helpful.

Arthrotomy of the left knee was performed through the usual meniscectomy incision and two tongue-like projections were immediately seen extending from a fat pad which filled the entire intercondylar space to the joint surface between the medial femoral condyle and the tibia. Following removal of the projections and remainder of the fat pad a defect the size of a quarter was seen on the femoral condyle which corresponded exactly to the point of intrusion. Inspection of the joint revealed no other abnormality, his postoperative course was uneventful and he has remained well.

In both these instances the gross and microscopic appearance of the fat and underlying synovial layer corresponded to that described earlier in the paper.

We think this condition of fat pad hypertrophy and intrusion is a definite entity and should be considered in the differential diagnosis of internal derangements of the knee. It is not simply a convenient wastebasket to be used when arthrotomy fails to reveal other causes of derangement. Since the size and shape of the pad varies in individuals, so too the trauma that it sustains will vary as will its response to this trauma. It is of course not easy to make a clearcut diagnosis of this condition preoperatively unless pneumoarthrograms are available, but we have had little experience with this diagnostic measure. There are occasions when this condition may be treated conservatively as minor impingements will respond to rest and heat. The swelling at the point of intrusion will recede and the fat pad will return to normal with minor fibrotic change following.

We have had several such instances; but since they have not been proven at operation, they are not included in this group.

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# THE TREATMENT OF AVULSION OF THE COLLATERAL LIGAMENTS OF THE KNEE\*

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THE immediate definitive surgical management of rupture or avulsion of the collateral ligaments of the knee is far from established. Immediate surgical repair and conservative treatment by prolonged immobilization are both championed by authority and experience. Boehler's<sup>1</sup> dictum, "Like all other ligaments, those of the knee joint unite satisfactorily if they are retained long enough in good position" is supported by Bristow,<sup>2</sup> Cubbins,<sup>3</sup> and Richman and Barnes.<sup>4</sup> On the other hand Smillie,<sup>5</sup> Abbott and his co-workers,<sup>6</sup> Jones,<sup>7</sup> and Brantigan and Voshell<sup>8</sup> are on the whole in agreement with Palmer of Stockholm<sup>9</sup> who in 1938 stated that, "There is a good chance of operative interference aimed at restitution of the normal anatomic conditions accomplishing complete *restitutio ad integrum*, without lengthening the therapeutic period."

During a fifteen-month period six young men were admitted to the Peter Bent Brigham Hospital shortly after sustaining severe injuries to the collateral and cruciate ligaments of the knee. All were injured in football. In two the forces were so severe as to produce lateral dislocation without nerve or blood vessel injury. Two others sustained avulsion of the medial or tibial collateral ligament together with rupture or sprain of the anterior cruciate ligament and two suffered avulsion of the lateral collateral ligament including the proximal end of the fibula. The basic data on these six patients are presented in Table 1.

## CASE REPORTS

The three types of lesions encountered among the six patients and the two methods of treatment employed are described in the following four representative histories:

J. S., (Case 5) a sixteen year old school boy, was struck on the anterior aspect of his right knee while playing sandlot football and was admitted to the hospital forty minutes after the injury. There was

gross deformity of the right knee with lateral and posterior displacement of the tibia and fibula on the femur. (Fig. 1.) Peripheral pulses, sensation and muscle function were intact. One hour after admission, under pentothal anesthesia, reduction was easily achieved and the extremity was immobilized in a well padded plaster cylinder from the groin to the toes with the knee in moderate flexion. One week later a lightly-padded plaster of paris spica was applied. The patient was discharged from the hospital twenty-four days after admission and resumed his classes seventy-one days after injury. The plaster cast was removed six weeks after application, crutches were discarded at three months and full activity was resumed two months later.

The result sixteen months after injury was satisfactory but not perfect. There was no atrophy and surprisingly little anteroposterior mobility of the tibia on the femur. There was approximately 10 degrees of lateral laxity of the extended knee but flexion was possible only 100 degrees from full extension.

This patient was fortunate in that he suffered no neurovascular injury and apparently no internal derangement. His disability, however, was prolonged and it appears unlikely that he will ever regain full flexion of the injured knee.

V. M., (Case 6) a twenty-five year old college fullback, while running on the offense was struck on the posterior lateral aspect of his flexed left knee (Fig. 2) sustaining a complete lateral dislocation. The tibia and fibula were rotated externally approximately 90 degrees on the intact lateral collateral ligament. The patella was dislocated laterally. Peripheral pulses and motion of the toes and ankle were normal. Within one minute of injury, on the playing field, reduction was very easily effected with almost no discomfort. A sponge rubber compression bandage was applied as well as a well padded plaster of paris cylinder from the toes to the groin with the knee in moderate flexion. Four days later the medial aspect of the knee was exposed through a long curved incision. (Fig. 3.) The medial collateral ligament was found detached from its tibial attachment and lay transversely within the joint, its distal end in the intercondylar notch. Both cruciate ligaments were ruptured at

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TABLE I  
KNEE LIGAMENT AVULSION

Case No.	Pa-tient	Age	Injury	Treatment		Disability			Result				
				Immediate	Definitive	Hos-pitaliza-tion (days)	Re-sumed Classes or Work (days)	Full Activity (weeks)	Time (Mo.)	Range of Motion	Atrophy	Lateral Laxity	Antero-posterior Laxity
1	W. T.	24	Lateral avulsion anterior cruciate sprain	Splint	Exploration and suture 20 hr. after injury	10	12	16	14	Normal	0	0	0
2	J. W.	22	Lateral avulsion anterior cruciate sprain	Splint	Exploration and suture 4 hr. after injury	5	10	8	2 1/2	Normal	3/4 in.	Slight	Slight
3	R. M.	21	Medial avulsion anterior cruciate rupture	Plaster cylinder	Exploration and suture 6 days after injury	20	21	11	3 1/4	Normal	0	0	Moderate
4	W. G.	23	Medial avulsion	Plaster cylinder	Exploration and suture 3 days after injury	14	120	20	14	Normal	0	Slight	Slight
5	J. S.	16	Lateral dislocation	Reduction 40 min. after injury; application plaster cylinder	Immobilization in plaster spica 8 days after injury	24	71	20	16	180°-75°	0	5°-10°	0
6	V. M.	26	Lateral dislocation	Immediate reduction one minute after injury	Exploration; removal medial meniscus; suture 4 days after injury	15	16	16	4	Normal	0	Slight	Moderate



FIG. 1. Anteroposterior roentgenogram of right knee prior to reduction. Case 1.

their proximal ends. The medial meniscus was displaced to a vertical position in the intercondylar notch. The meniscus was removed, the torn ends of the cruciate ligaments approximated and the distal end of the avulsed lateral collateral ligament sutured in place beneath the pes anserinus. Fine, interrupted cotton sutures were used throughout. Carefully supervised active motion was started on the eighth postoperative day. The patient was discharged from the hospital fifteen days after his injury and resumed his classes the next day. Crutches were discarded thirty days after injury and full activity was resumed three months later.

The end result at fifteen months was very satisfactory. The range of motion was normal, there was no atrophy, lateral laxity was less than 10 degrees and there was only slight anteroposterior laxity. Four months after injury the patient was able to participate in college track and baseball without difficulty.

W. T., (Case 1) aged twenty-four, was struck on the posterior aspect of his flexed right knee while playing in the backfield on offense in intramural college football. X-rays taken immediately after the accident disclosed avulsion of the proximal end

of the fibula (Fig. 4) and the extended knee could easily be adducted approximately 15 degrees from its normal position. The peroneal nerve was intact. At operation the morning after injury the lateral aspect of the joint was exposed. (Fig. 5.) The anterior cruciate ligament was stretched but was in continuity. The lateral meniscus and the anteromedial portion of the medial meniscus were intact. The avulsed fragment of the fibula was replaced and held with interrupted mattress sutures and the adjacent capsular rent was approximated with fine interrupted cotton. The patient was discharged from the hospital ten days after admission and resumed his classes the next day. All splints were removed thirty days after injury, crutches were discarded twelve days later and full activity was resumed at four months.

Fourteen months after injury the knee was apparently normal without atrophy, limitation of motion or lateral or anteroposterior laxity. Approximately the same result was obtained in another very similar case in which the patient was operated upon four hours after injury (Case 3, Table 1).

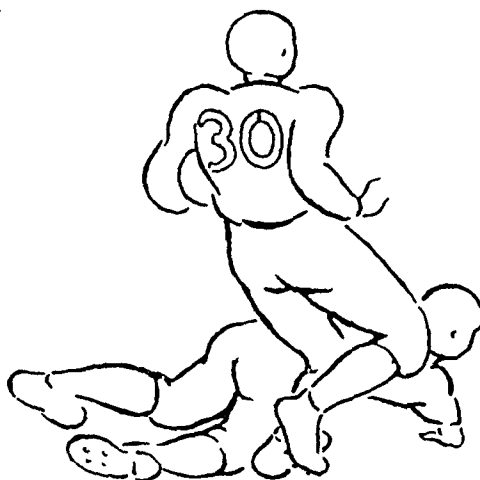
R. M., (Case 3) a twenty-one year old college undergraduate, while carrying the ball in an intramural football game, suddenly changed direction twisting to the right. His right foot was fixed to the soft ground by cleats. There was immediate pain on the medial aspect of the knee and examination a few moments after the injury disclosed almost no resistance to approximately 15 degree abduction of the extended knee. (Fig. 6.) Six days after the injury the medial aspect of the joint was exposed. The medial collateral ligament was avulsed from its tibial attachment and a transverse tear into the joint extended from the medial collateral ligament to the patella. The anterior cruciate ligament was ruptured in its upper portion. The menisci were intact. (Fig. 7.) The ends of the cruciate ligament were approximated and the tibial collateral ligament replaced beneath the pes anserinus. The patient was discharged from the hospital twenty days after his injury and resumed classes the next day. All splints were removed five days later and crutches were discarded thirty days after injury. Full activity was resumed at eleven weeks.

When examined six months later the knee was almost indistinguishable in appearance and function from its fellow. Range of motion was normal; there was no atrophy or lateral laxity and only slightly more anteroposterior mobility than normal.

In a similar case (Case 4, Table 1) disability was apparently prolonged, full activity being resumed five months after injury. However, the patient was a printer and could not return to work until he could stand for a full working day.



2A



2B

FIG. 2. An enlargement from motion picture film showing the injury which produced dislocation of the left knee. The patient wears the numerals 30 on his jersey; B, drawing made from motion picture film. Case 2.

#### COMMENT

**Diagnosis.** In the present series it was possible to examine every patient within a few moments of injury. Determination of abnormal mobility could be made with assurance and little or no discomfort. In patients seen hours or days after injury edema and muscle spasm can make examination difficult and uncertain. Moore,<sup>10</sup> Abbott and his colleagues<sup>6</sup> and Hitchcock,<sup>11</sup> have advised aspiration, manipulation and roentgen examination under anesthesia. The latter recommends this procedure for every knee injury in which marked effusion occurs immediately after injury. In none of the present series was effusion present and it is assumed that blood and joint fluid escaped through the rents in the capsule which were demonstrated in every case. It would therefore seem reasonable to reserve diagnostic manipulation under anesthesia for severe knee injuries, particularly those which do not exhibit effusion but instead present the boggy, diffuse, subcutaneous edema which developed in those patients in the present series in whom operation was delayed.

Whether an accurate diagnosis is made immediately after the injury or later, 15 degrees of abduction or adduction of the extended tibia on the femur can be considered diagnostic of separation of the collateral ligament and rupture or stretching of the anterior cruciate ligament. This has been established by the

experimental and clinical work of Palmer,<sup>9</sup> Brantigan and Voshell,<sup>8</sup> and Abbott and his co-workers.<sup>6</sup>

**Treatment.** Satisfactory results have long been known to follow prolonged immobilization



FIG. 3. Medial exposure of left knee four days after injury; the joint is held in valgus. The avulsed medial collateral ligament has been withdrawn from the joint and the meniscus from the intercondylar notch. A suture has been inserted into the ends of the anterior cruciate ligament. Case 2.

in a considerable proportion of patients. However, precise surgical restoration of continuity is always to be preferred when it can be achieved. The risks of operation are slight and the advantages to be gained are considerable. In a certain proportion of patients the avulsed ligament may lie within the joint as Palmer,<sup>9</sup>



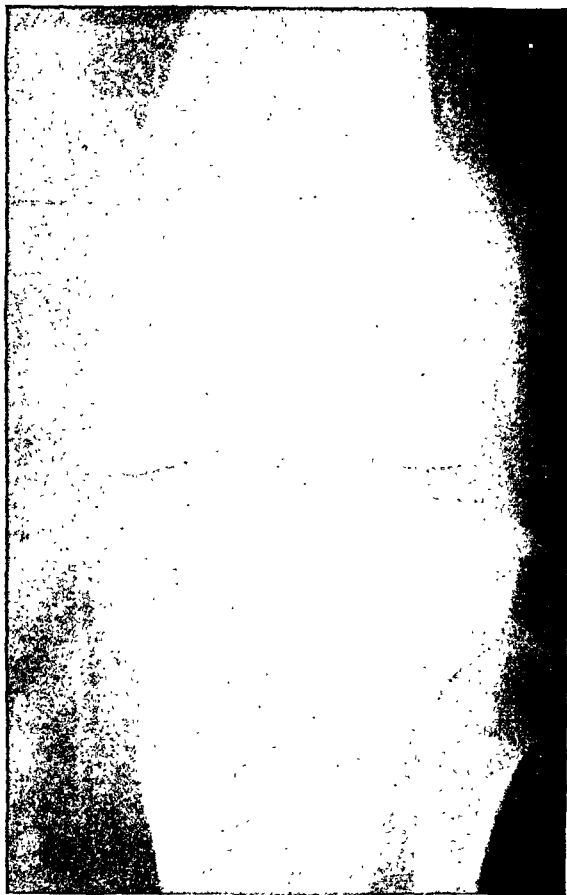


FIG. 4. Avulsion of the proximal end of the right fibula. Case 3.

Smillie<sup>5</sup> and others have pointed out and as was the case in the second patient of the present series. This situation cannot always be determined by examination alone. Also, in a certain number of cases displacement or another injury to the menisci may have occurred. Hulten<sup>12</sup> found separation of the meniscus from its medial attachments in 13 per cent of his abduction experiments on cadavers.

The disposition of the injured anterior cruciate ligament is a matter of considerable debate. The experience of the Harvard Athletic Association<sup>13</sup> has been in agreement with that of Darrach<sup>14</sup> who believed that formal operative restoration of these ligaments was not necessary. The knee can be considered as a physiologic unit. The loss of one of its components is not serious and if this component is the anterior cruciate ligament it is even insignificant provided that the musculature of the knee is normal. This is merely a restatement of Sir Arthur Keith's "Law of



FIG. 5. Lateral aspect of right knee at operation; an instrument indicates the fracture face of the proximal fragment of the fibula. Case 3.

Ligament."<sup>15</sup> The ruptured anterior cruciate ligament was approximated twice in the present series (Cases 2 and 6) but this was not done with any thought of restoring its original length or strength but rather to establish continuity so that the ragged ends would not serve as a future source of internal derangement. In all of the patients of the present series an active vigorous program of exercises was instituted at the earliest possible moment and continued to the point of maximum improvement. Exercises of the resistance type recently described by deLorme and Watkins<sup>16</sup> were employed.

**Dislocations.** Fortunately neither of the two dislocations of the series suffered nerve or blood vessel injury. Interruption of the vascular supply to the leg accompanying dislocation at the knee must take the highest priority in treatment. Reduction of the dislocation must be carried out at the earliest possible moment.<sup>17</sup> If restoration of arterial supply does not follow reduction, exploration of the popliteal space, inspection of the damaged segment of artery and, if necessary, excision or replacement by a vein graft should be carried out at once followed by lumbar sympathectomy and heparinization. The experience of the two world wars with regard to injuries to popliteal arteries is discouraging<sup>18-21</sup> and only by such vigorous measures can gangrene be averted. When arterial supply to the leg is intact after reduction, early exploration and repair of the avulsed ligament must be regarded as the treatment of choice. The contrast between the



FIG. 6. Roentgenogram of right knee in abduction prior to operation. Case 4.

FIG. 7. Medial aspect of right knee at operation; the avulsed medial collateral ligament is seen in the lower left. A suture has been inserted into the proximal end of the ruptured anterior cruciate ligament. Case 4.

two dislocations in the present series from the point of view of disability, both in time and eventual degree, is striking.

The satisfactory end result achieved by conservative therapy in Case 1 must be regarded as fortuitous in view of the extensive intra-articular derangement disclosed at operation in Case 2.

#### SUMMARY

1. Six cases of avulsion of the collateral ligaments of the knee including two lateral dislocations are presented.

2. In five cases early exploration and suture of the avulsed ligaments were carried out with prompt restoration of function and minimal permanent disability.

3. Conservative treatment of one dislocation by prolonged immobilization in plaster after reduction resulted in loss of full flexion of the knee.

4. Diagnostic manipulation under anesthesia is recommended for severe knee injuries, particularly those which do not exhibit effusion.

5. Complete collateral ligament avulsions should be explored and repaired within a few days of injury. The procedure carries little risk, establishes the diagnosis with precision and lessens disability both in time and degree.

6. Obvious dislocation of the knee should be reduced at the earliest possible moment. Associated injury to the popliteal artery takes the

highest priority in treatment and exposure with resection or replacement of the damaged vessel should not be delayed.

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DISCUSSION OF PAPERS BY DRS. HANLON AND ESTES, STACK AND CHASTEN, AND QUIGLEY

W. L. ESTES, JR. (Bethlehem, Pa.): I have very little to add to Dr. Hanlon's presentation. This was largely his investigation and his work. However, there are three or four points which I would like to emphasize.

His report concerns trauma to the joint which is involved in osteo-arthritis and not trauma simply to an individual who has osteo-arthritis elsewhere than the traumatized area.

Secondly, the disability in this series was found due largely to the presence of osteo-arthritis rather than specifically to the trauma. The major portion of the disability arose from the fact that the individual injured had osteo-arthritis rather than the severity of the trauma; that is, only those cases which were involved in the mild trauma have been studied. It is possible that a further report will consider the problem of major trauma such as fracture or dislocation in association with osteo-arthritis.

Finally, I think we might summarize this report as follows:

(1) Osteo-arthritis aggravated by trauma should be considered as a distinct clinical problem; (2) the mechanism of injury indicated that falls were responsible in about 44 per cent of the cases, automobile injuries in 21, lifting heavy objects in 14 and direct blows in about 6; (3) the average duration of symptoms in these patients when applying for treatment was approximately one year; 80 to 86 per cent were cured indicating that even after a considerable interval following the trauma with persistent disability, rehabilitation should not only be undertaken but is still quite possible; (4) 56 per cent of the patients had litigation in the form of compensation or liability claims;

(5) the average time lost from work in this group was approximately thirty weeks; (6) it was found that 95 per cent were considered to have inadequate body mechanics.

KEILLOGG SPEED (Chicago, Ill.): I wish to say a few things about Dr. Stack's paper which is an excellent plea for arthrotomy on the knee for wide exploration in any suspected case of internal derangement. There is great difficulty in diagnosing an isolated catching or tearing of the fat pad in comparison to cartilage or other injuries because the x-ray will be of no assistance. It takes clinical experience and horse sense and perhaps a thorough understanding of the anatomy which he outlined for us even to presume on such a diagnosis.

I have found this fat lesion, as you all have, a great many times, often combined with the cartilage avulsion or injury. It is not always necessary to remove the cartilage; that would depend on how loose it is. But the fat pad may be widely cut away and removed without any fear of resulting difficulty. I have done it over a hundred times in various arthrotomies on the knee joint. Even when a constrictor is used on the leg and there will be hemorrhage into the joint after the fat is removed, one does not hesitate to perform a proper resection.

In isolated findings of fat pad injury I have found them ecchymotic and even dripping with blood without any other lesion in the knee joint and, also, as greatly prolonged or pedunculated masses, wagging free in the joint and caught between the articulating surfaces as Dr. Stack mentioned.

Occasionally they are adherent to the intercondyloid notch or the cruciate ligaments and drawn out by that adherence.

Finally, I do not believe that they are the cause of malacia of the joint or of the articular surface of the patella. I think they are secondary to the general change in the joint or the cartilaginous change in an osteochondritis and that they are somewhat in the nature of the pannus that forms on the eye in cases of irritation or foreign body near the limbus or in the cornea. That adherence and attachment and extension of the fat pad may bring capillary vessel attachment to the changes in the knee joint.

WILBERT H. MCGAW (Cleveland, O.): It was a pleasure to hear Dr. Stack's presentation and I agree with him that real pathologic changes do occur in the fat pad. We have found four main types of fat pad lesions: (1) This type is the most common and involves an increase in size and consistency and is usually associated with areas of fibrosis which seem to be the seat of repeated traumatic pinching. (2) The lower edge of the fat pad becomes adherent to the anterior cornu of the medial meniscus. I believe that this type is more likely to occur in so-called hypermobile menisci. These patients obtain complete relief with removal of a portion of the fat pad and the anterior portion

of the meniscus. (3) The third type of change we have found in cases in which a fragment of bone or cartilage has become adherent to the fat pad. These pieces of bone, such as are produced in osteochondritis dissecans, may cause thickening, fibrosis and adhesions in the anterior part of the joint. A portion of the fat pad must be removed to excise some of these fragments. (4) The fourth type is the seat of acute trauma showing laceration of the synovia with a hematoma filling all or part of the fat pad. Although the fat pad is well protected, a direct blow such as falling on the edge of a stair can easily produce a direct contusion to the fat pad which in turn produces swelling and bleeding. The ligamentum mucosum likewise can be torn by a direct blow.

Dr. Quigley deserves commendation for his excellent paper on the treatment of collateral ligament injuries. The early surgical repair following an accurate diagnosis undoubtedly affords the best early results in acute ligament injuries.

HARRISON L. McLAUGHLIN (New York, N.Y.): I would like to speak briefly about Dr. Quigley's paper which was very informative and well documented.

I think it would be even more informative if he would state his principles of management of borderline cases. I would like to know what he would do (1) in the presence of less than 15 degrees of instability and (2) in the presence of bilateral collateral tears, assuming the essential circulation was intact.

One must commend him for his philosophy of management of the anterior cruciate tears. This ligament has been accorded much more functional importance than the clinical experiences of most surgeons warrant. As far as I know, no patient on our service has had an anterior cruciate repair except for the purpose outlined by Dr. Quigley, that is, to prevent the loose ends from becoming caught between the bones to produce subsequent internal derangement. A great many more have been excised than have been repaired and I think it is safe to state that follow-up results have failed completely to indicate or allow any identification of the presence of instability or dysfunction in knees with known absences of the ligament.

I would like to emphasize one point that Dr. Quigley did not. Some months ago I had the opportunity of seeing the patients on whom he has reported. Rarely have I ever seen a more satisfied or, from a surgical viewpoint, a more satisfying group of results.

C. R. HANLON (closing): It was impossible to cover what we had developed in our study. In a 93 per cent follow-up we found that it cost \$52,306 to control and treat these patients. If it cost that much to treat eighty-five patients, on the basis of 150 million people in this country we might estimate that it would cost 92 billion dollars a year for the Government to take over.

JAMES K. STACK (closing): I wish to thank the doctors for discussing the paper and I want to assure Dr. Speed that I did not mean for a moment to leave the impression that these cases had been diagnosed preoperatively because they were not. Our percentage was very poor. Practically all of the patients were operated on either for acute tears of the normal meniscus or with the thought that there was something wrong with a degenerated meniscus in the older group of people.

The point you and Dr. McGaw brought out about the microscopic changes that take place in the pad is, of course, true. We did not have time to go into that during the formal presentation.

T. B. QUIGLEY (closing): I should like to thank Dr. McLaughlin for his, as always, penetrating questions.

As to the borderline case, for the past four years we have been trying to make some sense out of sprains which we see in considerable number. We try to grade them on a basis of I to IV, I being the least degree of injury to a ligament which one can conscientiously call a sprain and IV being complete avulsion.

Now, would we operate on patients with grade III sprains? I think we might be tempted to do so. In none of the patients in the present series was there any doubt about the fact that they had grade IV sprains or complete avulsions. I think if there were a doubt as to whether or not an arthrotomy or an exploration were indicated, examination under anesthesia with x-rays available and preparations to go ahead with exploration if indicated is in order.

As was stated, 15 degrees of abduction or adduction is established as the critical level of rupture of either collateral ligament and the anterior cruciate.

As for bilateral tears, I have never seen one. They must be very rare. In perusing the literature on this subject during recent months I came across no cases. Should such a case appear, I am certain that the greatest priority in treatment would be the neurovascular situation. Granted that is intact, I believe that both sides of that knee should be repaired.



# OPERATIVE TECHNIC FOR CALCIFIED TENDONS ABOUT THE SHOULDER JOINT

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**C**ALCIFIED tendinitis and its secondary subacromial bursitis are very common conditions. In the past there has been

of the calcium deposits and their relation to and condition of the bursa. If these facts are known, the proper treatment may be selected.



FIG. 1. Case of tuberculosis of shoulder treated for many years for bursitis. Note large cystic areas in head of humerus and narrowing of shoulder joint.

a tendency to call all cases subdeltoid bursitis and treat them as such. Other cases that we have seen classed and treated as "bursitis" are: acromioclavicular arthritis, tuberculosis, tenosynovitis of the long head of the biceps, capsular tears, bone islands in the head of the humerus partial paralysis of the serratus anterior muscle, radiculitis and caisson disease. (Figs. 1, 2 and 3.)

We believe that with a consideration of the anatomy of the shoulder, a study of the symptoms, a careful physical examination and proper x-rays an accurate differential diagnosis of shoulder conditions can be made; and if a case is one of calcified tendinitis, one can definitely determine the location and condition



FIG. 2. Shoulder with symptoms and an unrelated bone island mistaken for calcium deposit.

Some patients will get well untreated,<sup>1</sup> some respond to simple procedures and some will not get well until given surgical relief.

## SURGICAL ANATOMY

To understand the pathologic changes and symptoms produced by calcified tendinitis and subacromial bursitis, it is necessary to recall that the capsule of the shoulder joint in its superior and posterior portions blends with the flat expanded tendons of the supraspinatus, infraspinatus and teres minor muscles as they pass to their insertions on the greater tuberosity of the humerus.<sup>2</sup> The subscapularis muscle differs from these muscles by being separated from the capsule by a large subscapular bursa. This bursa usually connects with the shoulder joint. We thus rarely see a calcium deposit in this bursa. The long tendon of the biceps muscle is invested by a fold of joint synovia which is carried in the form of a tubular prolongation into the intertubercular sulcus and ends blindly opposite the insertion of the pectoralis major muscle.<sup>2</sup> We have not seen calcific deposits in this sheath but teno-



FIG. 3. A case of severe acromioclavicular arthritis previously treated as bursitis.

synovitis occurs not infrequently. The supraspinatus tendon lies above and forms the roof of the shoulder joint. It also forms a good part of the floor of the subacromial bursa. This, one of the largest bursae in the body, extends further downward between the deltoid muscle and the greater tuberosity and on upward under the acromium and the coraco-acromial ligament. (Fig. 4.) The bursa tends to disappear under the acromium when the arm is abducted.

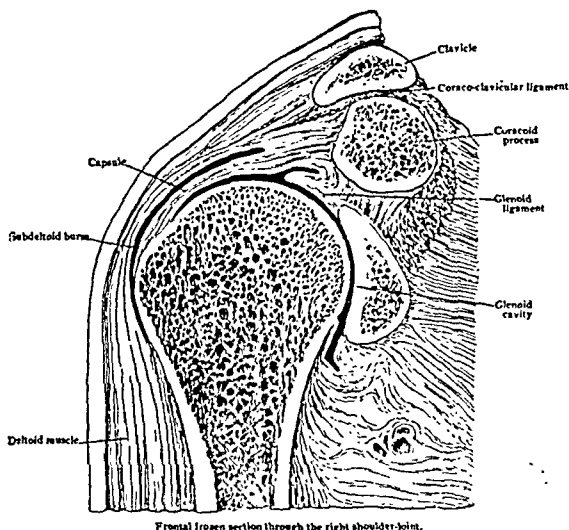
One can readily believe that a heaped up calcified deposit in one of the capsular tendons may well encroach on the floor of the bursa and interfere with motion. Furthermore, when the calcium in the tendon ruptures, it usually passes into the bursa. We have seen it break through into the shoulder joint but such instances are exceedingly rare. If the supraspinatus tendon is completely divided, the shoulder joint and bursal sac become one continuous cavity. In such a case there will probably be no calcific deposit in the torn tendon.

#### ETIOLOGY

We do not definitely know what causes calcified deposits in tendons. They have been considered as being laid down in an attempt to repair a degenerative process, to repair multiple small tendon tears and as a part of some metabolic process. Codman believes that trauma is the most likely.<sup>3</sup> Wilson leans toward the degenerative theory.<sup>4</sup> Not so uncertain is the sequence of events in subacromial bursitis. Barring the very rare primary, distended, non-calcified subacromial bursa and the rare suppurative type,<sup>5</sup> the ones we commonly see are produced as follows:

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The calcium is deposited in the tendon. It heaps up as a soft toothpaste-like substance or hard mass. It may lie quiescent a long time but sooner or later nearly all such deposits act like foreign bodies and as they are rotated under the bursa the latter becomes inflamed.



Frontal frozen section through the right shoulder joint.

FIG. 4. Frontal view of frozen section through the right shoulder joint. (From Piersol's Anatomy.)

Also when the shoulder is abducted, the bursa becomes pinched between the acromion and the calcific mass, liquification or softening of the calcium takes place—this causes distention—and finally the deposit usually breaks through into the bursa. It may be absorbed but, if not, the bursa becomes inflamed to varying degrees. There is pain and disability and the patient seeks medical advice. There is usually no history of a specific trauma; the shoulder just begins to ache.

We divide the patients into chronic, subacute and acute types.

#### SYMPTOMS

The chronic patient has had an intermittently aching shoulder over a period of months or years. Due to spasm of the neck muscles pain may radiate up the side of his neck or it may go down the arm toward the insertion of the deltoid muscle.

The subacute patient is one with a chronic case who has interval flare-ups following unusual exercise. He gets discouraged when he tries to play tennis or golf. He cannot sleep on the affected side.

The acute case occurs when the patient has such an extremely painful shoulder that he

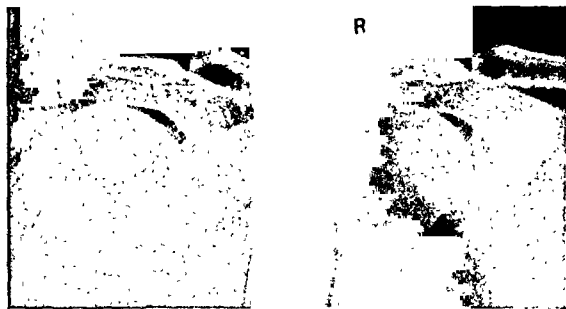


FIG. 5. Soft deposit at time of acute symptoms and six weeks later; patient had no treatment. These soft deposits will clear up without treatment more quickly with irrigation, x-ray irradiation or diathermy. However, removal by surgery is the most specific form of treatment.

cannot move it. He is unable to sleep except with heavy sedation. He walks the floor and he has pain in the arm similar to pain of an abscessed tooth.

#### PHYSICAL EXAMINATION

The chronic patient has limitation of rotation especially when the shoulder is at the same time held in abduction. There is point soreness over the calcific deposit. There is usually atrophy of the supraspinatus and especially of the deltoid. There may be localized swelling visible and palpable.

In the subacute patient motions in the shoulder are restricted in accordance with previous usage and activity. There is point tenderness over the calcified areas.

The acute patient holds his arm to his side. His axilla is wet with perspiration. His elbow is flexed. All motions are painful. There is exquisite tenderness over the bursal area.

#### X-RAYS

We seldom see ideal roentgenologic views. The shoulder is painful and the technician does not know how to take required views without hurting the patient. He therefore gives us poor films. However, proper and adequate films can be taken and the arm and shoulder not moved if the technic of Raymond Lewis is used. Lewis makes roentgen ray studies of the aching shoulder by leaving the arm and shoulder in a sling, letting the patient stand or sit and rotating the patient's body, rather than the shoulder, to get the desired projections.<sup>6</sup> If proper films are not available, proper evaluation of the case and appropriate treatment cannot be rendered. (1) The chronic



FIG. 6. Case of mixed soft and hard deposits, the large, soft deposit being in the supraspinatus tendon and the small, hard deposit in the teres minor tendon. These mixed deposits are always best treated by surgery.

patient has a hard fixed deposit in one or more tendons. (2) The subacute patient may have a soft deposit which is irregular, mottled and he may have one or more hard deposits also. (3) The acute patient reveals a cloudy diffuse shadow in or under the bursa and rarely in the shoulder joint. There may also be other hard or soft unruptured deposits.

#### TREATMENT

One clinic will treat most patients with x-ray irradiation, another with various forms of heat and diathermy, another will use intramuscular drugs. Rest, sling and sedatives will relieve many. All of these forms of treatment are particularly adaptable to subacute and acute types. Patients thus benefitted usually have one large soft deposit superficially placed in a tendon, or already ruptured into the bursa. (Fig. 5.) Likewise such patients may be treated by aspiration and irrigation with the two needle technic.<sup>1,7,8</sup> We still find that this offers dramatic relief to the acute shoulder.

We believe that operative treatment is indicated in all patients with unruptured single or multiple hard deposits and in all cases with mixed hard and soft deposits. (Fig. 6.) Surgery for the single soft deposit is specific but as indicated above other therapy may be more practical in certain cases.

#### OPERATIVE TECHNIC

There are three objects of the operation: (1) the tension in the distended tendon or bursa is relieved, (2) the calcium which acts

as a foreign body is removed and (3) the defective area in the tendon is revascularized. We never excise the bursa; we open its outer layer and we do not suture it at the end of the operation. The tendon heals after removal of calcium without laying down more calcium.

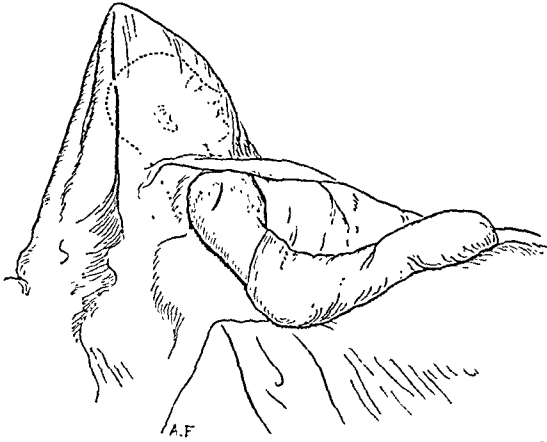


FIG. 7. Draping of shoulder should be such that the extremity may be easily moved in any direction. The patient should be in semi-sitting position, body being flexed to about 45 degrees at the hips. We like the transverse incision although the longitudinal one is equally good.

This would suggest that the calcium was originally laid down in a degenerated tendon and not in a torn tendon. If at operation there are several deposits and any one is left unopened, the patient's symptoms will not be completely relieved. If the incision is carried too low on the shaft of the humerus, bleeding is encountered and a nerve branch may be divided. We prefer a light general anesthetic.

**Procedure.** The shoulder and upper extremity are so draped that the arm is freely movable in all directions. (Fig. 7.) A 2 inch vertical or transverse incision is made over the shoulder in the deltoid region just below the acromium. The incision is carried through the skin and outer deltoid fascia. The muscle fibers are split and retracted. The deep layer of deltoid fascia is very thin. The subdeltoid bursa is next approached and is immediately incised and contents, if any, are evacuated. The bursa will often show varying degrees of inflammation but as a rule is not very thickened. It is very easy to go through both layers of the bursa especially when they are adherent, in which instance there is some tendency to bleed. As soon as the bursa is opened long narrow retractors like the McBurney retractors are used to spread the deltoid muscle and the outer bursal edges.

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The flexed elbow is grasped and the shoulder is then rotated exposing the entire cuff. Specifically we carefully inspect the tendinous attachment areas of the subscapularis, the tendon of the long head of the biceps, the supraspinatus, the infraspinatus and the teres

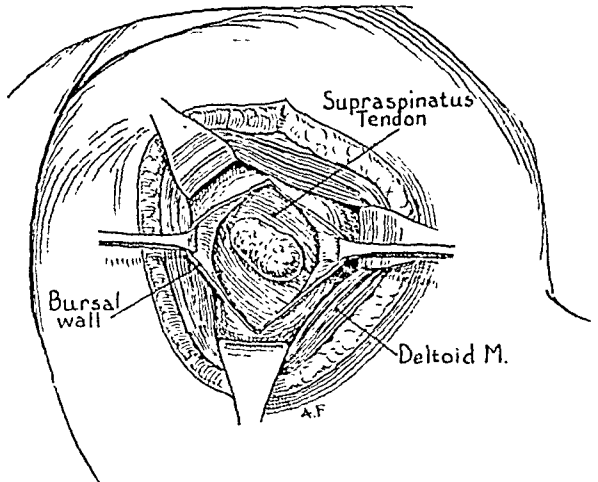


FIG. 8. The fibers of the deltoid muscle are separated; the bursa immediately seen. By rotating the shoulder the tendons are seen blending with the capsule. Deposits appear as elevated, yellowish white areas in the tendon.

minor muscles. (Fig. 8.) The calcium often is placed as a white or yellowish elevation in the tendon just as it passes into the tendinous cuff. The calcific area is then opened in the direction of the fibers of the tendon with a small knife and calcium is scooped out with a tiny curette. Other similar areas are so treated. Care is exercised to be sure that no calcific deposit is left in any one of the tendons. The bursa is not resutured. Quite obviously at this time if any other disorder is detected, it is dealt with appropriately. In closing the wound only the outer layer of the deltoid fascia is sutured, then the subcutaneous fascia and skin.

#### POSTOPERATIVE TREATMENT

A simple small dressing is applied with elastic adhesive over the wound and the arm is put in a sling. The next day external heat is applied. The patient is requested to use the shoulder and arm. We usually keep them in the hospital two to four days postoperatively. Forty-eight hours after operation we ask the patient to bend over and let his arm swing like a pendulum. The patient usually returns to his work on the fifth or sixth postoperative day with good use of the shoulder but restricted in extreme usage for one to several



more weeks. The aching pain in his shoulder disappears almost immediately after operation.

#### SUMMARY

In this paper we have attempted to classify patients with calcified tendons and those with secondary subacromial bursitis about the shoulder joint. We have mentioned the main points in surgical anatomy. We have described symptoms, physical findings and x-ray findings on different types of cases. We have suggested what we believe to be the best form of treatment in each type of patient and we have described in some detail the operative treatment.

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#### DISCUSSION

BOARDMAN M. BOSWORTH (Bronxville, N. Y.): Some ten years ago I had the opportunity of studying shoulder fluoroscopy on some 12,000 shoulders in the period of three years at annual examinations at the Metropolitan Life Insurance Company. My interest was to discover the incidence of these de-

posits in the general population, which I found to be 3 per cent, or 3 out of 100. These were deposits that had not given any symptoms at all but were merely picked up on routine examination. I should like to make a plea for fluoroscopic examination of the shoulder for suspected calcium deposits if they are not found on the routine x-ray films. Time and again I have picked up calcium deposits by fluoroscope which were not found in the routine three-plane views by x-ray.

NICHOLAS J. GIANNISTRAS (Cincinnati, Ohio): There is one question I would like to ask Dr. Patterson. I agree entirely, and I am sure all of us do, as far as surgery is concerned, but what about the period of rehabilitation? How long does it take him and what does he do? What panacea, or what magic does he have that these shoulders get well soon after surgery? The ones that I have done have taken a long time. Their period of disability has been a minimum of six weeks, in spite of very carefully regulated daily physiotherapy by well trained personnel.

RUSSEL H. PATTERSON (closing): To answer the last question first, the patient is usually in the hospital three or four days. He usually returns to his work within seven days, but he does not return to work with full range of motion in the shoulder. Following the operation the acute toothache-like pain is gone, the patient can begin to use the shoulder and within a few days to a few weeks his shoulder will be restored to full use. We have no panacea for shortening this interval. We have not so far had any recurrences following the operative treatment.

We admit that around 80 per cent of all of these deposits will recover and do recover without treatment. What we are trying to show is that in the remaining group there are various treatments that one can use, and we have tried to make suggestions as to what type of treatment will suit what type of case.

We are grateful for Doctor Bosworth's remarks. His study has been very broad. We believe that if the calcium about these shoulders is not absorbed, eventually it will cause symptoms in every case.



# USE OF BANK BONE IN THE TREATMENT OF CENTRAL LESIONS OF BONE

BRADLEY L. COLEY, M.D. AND NORMAN L. HIGINBOTHAM, M.D.

*New York, New York*

BUSH<sup>2</sup> and Wilson<sup>5</sup> separately reported in 1947 their experiences in two orthopedic hospitals with homogenous bone grafts. They made use of a deep-freeze to store bone obtained at operation or from amputated specimens. They established the fact that refrigerated bone serves as a useful source of bone transplants and that such bone behaves in the host much as does autogenous material.

Additional experimental and clinical experience by Bush and Garber<sup>3</sup> further established the safety and utility of the method and Wilson<sup>6</sup> reported an impressive follow-up study of 214 patients who were subjected to 278 operations in which sterile homologous bone grafts were used. Wilson<sup>6</sup> concludes—

“1. With careful technique homologous bone grafts may be preserved for long periods of time for surgical use.

2. Such grafts are well tolerated by human tissues and the risk of infection is no greater than with autogenous grafts.

3. The healing of such grafts takes place by a process of invasion, absorption and replacement similar to that of autogenous bone grafts.

4. The results obtained are identical with those from the use of autogenous grafts except that in some instances the healing appears to be a little slower.

5. The operation of the bone bank is safe and practical. It offers great advantages to the patient and the surgeon from the standpoint of availability, abundance and the elimination of the necessity of secondary operations to obtain bone.”

It seems unnecessary to repeat here details which both Bush and Wilson have given concerning the organization and operation of the bone bank. Instead we wish to describe our experiences with this method during a fifteen-month period in which it has been in use on the Bone Tumor Service at Memorial Hospital. During this period we have had a bone bank and have kept an ample supply on hand which

has been derived almost entirely from ribs resected on the Thoracic Service by Dr. William L. Watson and his associates. Based



FIG. 1. A, typical unicameral bone cyst in a six year old boy; B, five weeks after curettage, cauterization and implantation of homologous rib chips.

on the work of Abbott et al.<sup>1</sup> we would emphasize our belief that ribs constitute an almost ideal source of homogenous bone. Ribs can be converted readily into chips, can be cut with the motor saw into long strips for onlay grafts or can be used in large sections or as match-stick grafts. Being composed of cancellous bone it is believed that they are incorporated in the host more rapidly than cortical strips taken from the tibia. (Fig. 1.)

During the period covered by this report there were sixteen cases (Table 1) in which bank bone was used. Seven were instances of bone cyst (Fig. 2), four were central chondromas (Fig. 3), three were giant cell tumors and one each of fibrous dysplasia and eosinophilic granuloma. (Fig. 4.) Of the bones in-

volved, five were of the humerus, three of the femur, two of the tibia, two were phalanges of the fingers and one each of ilium, sacrum, radius and ulna. The ages of the patients ranged from two to fifty-eight years with an average age of twenty-six; four were under

humerus including the head and replacement with a corresponding length of the upper portion of the fibula. It might be preferable to continue to use autogenous bone for such large transplants. However, with increasing experience and further indications of the

TABLE I  
BANK BONE—SUMMARY OF SIXTEEN CASES

No.	Name	Age	Sex	Bone	Lesion	Date of Operation	Remarks
1.	M. H.	6	M	Humerus	Cyst	12/9/48	
2.	J. W.	6	F	Humerus	Cyst	7/26/48	
3.	V. N.	15	F	Femur	Cyst, rec.	6/7/48	Previous operation 9/19/42
4.	A. A.	13	F	Sacrum	Cyst	3/15/48	Previous operation 12/8/47
5.	R. B.	2½	M	Ulna	Cyst, rec.	4/7/49	Previous operation 10/1/48
6.	S. S.	25	M	Femur	Cyst	5/5/49	
7.	J. E.	8	M	Humerus	Cyst	5/19/49	
8.	B. G.	53	F	Humerus	Chondroma	11/8/48	
9.	S. B.	36	F	Phalanx	Chondroma	2/16/48	
10.	F. B.	41	M	Phalanx	Chondroma	3/21/49	
11.	P. C.	36	M	Humerus	Chondroma	2/28/49	5 previous operations; Lane plate
12.	E. B.	58	F	Tibia	Giant cell tumor	10/4/48	Infection
13.	E. L.	44	F	Radius	Giant cell tumor, rec.	7/19/48	Previous operation 9/23/46
14.	M. H.	37	F	Ilium	Giant cell tumor, mal.	5/24/48	
15.	T. G.	2	M	Tibia	Eosinophilic granuloma	6/23/48	
16.	R. M.	31	M	Femur	Fibrous dysplasia	5/17/48	

seven years of age. Five of the fifteen patients had been operated upon previously and one of these had undergone five previous operations for the condition for which the operation for use of bank bone was undertaken.

Complications were conspicuously absent save in one patient whose wound infection supervened and later bone fragments had to be removed. The operation was for a giant cell tumor of the tibia and infection was attributed to the fact that one of the operating team had a beginning severe nasopharyngitis. Primary wound healing was achieved in the other fifteen patients or 93.7 per cent.

Ultimate fate of transplanted bank bone was satisfactory in five patients who were operated upon long enough ago to permit of evaluation (one year or more). The progress of the others is satisfactory to date.

Elsewhere<sup>4</sup> we discussed the use of massive tibial transplants (autogenous) to repair defects following segmental resection of such bones as the humerus and ulna. Since that report we have added four more cases, two lesions of the radius and two of the humerus, one of which had resection of the upper two-thirds of the

expanding field of usefulness of homologous grafts, subsequent results may justify employment of bank bone even in these cases.

The only question with which we have been considerably concerned is the safety of using bone removed from patients with known cancer. It is realized that a medicolegal problem is posed here and one for which we as yet do not know the whole answer.

Care is taken to use ribs which are apparently free of bone metastasis. Yet the possibility of a minute focus of carcinoma in such ribs cannot be denied. Nor does freezing at subzero temperatures constitute a safeguard since animal tumors are known to survive such exposures. The one factor that we believe constitutes an adequate measure of safety is our confidence in the inability of malignant tumors from one patient to survive and grow in another. So far as we are aware nothing in the past has been published that would support a contention that known cancer can be transmitted by transplantation in humans. However, we do not have much actual accumulated evidence on this point and human experiments along these lines would be extremely difficult



FIG. 2. A, less common location of unicameral bone cyst in a six year old girl; B, six months after curettage and implantation of chips of rib from the bone bank.



FIG. 3. Enchondroma of the middle phalanx of the third finger; the bone bank conveniently provided grafts obviating the necessity of a second operative wound to obtain autogenous bone.

to conduct on a wide enough scale and follow for a long enough period to offer truly convincing evidence.

For the time being we consider it safe, with proper precautions, to use bank bone taken from ribs of patients who have had exploratory thoracotomies for lung or mediastinal tumors. But if it were practical to obtain bone from presumably non-cancerous patients, we would perhaps be running less risk of medicolegal

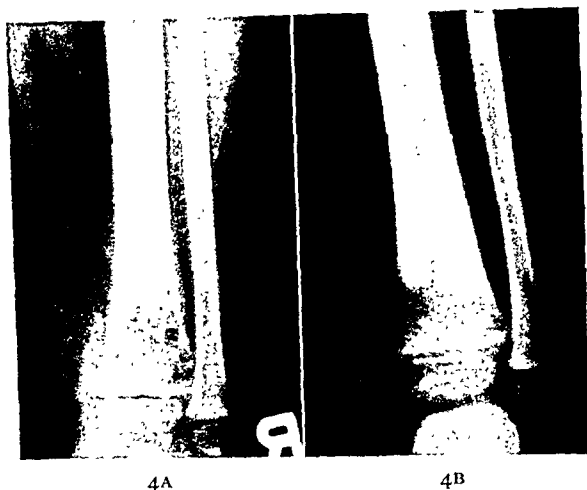


FIG. 4. A, eosinophilic granuloma in a two year old boy; B, result eight months after curettage packing the cavity with chips of rib from the bone bank. Primary wound closure was employed in all our cases.

complications and it is also possible that we might be exposing our patients to less risk.

#### CONCLUSIONS

Bank bone has been used at Memorial Hospital for the past fifteen months for sixteen patients. There was one wound infection. Bone regeneration in the area filled with homologous bone particles has been satisfactory. In some specialized procedures autogenous bone may be preferred but it would seem reasonable to assume that homologous bone would serve equally well. The question is raised as to the advisability of depending upon bone removed from known or suspected cancer patients.

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## DISCUSSION

BRADLEY L. COLEY (New York, N. Y.): I shall limit myself more or less to a discussion of the possible hazard of using bone taken from a patient operated upon for at least a questionable tumor of the mediastinum or lung. As Dr. Higinbotham implied, we take great pains to assure that these ribs are not affected. They certainly show no roentgenographic evidence of metastasis but I think one must grant that any patient with cancer anywhere may have a microscopic focus of the disease in any bone in the body even though the chances are extremely slight.

We had hoped that freezing for long periods at sub-zero temperatures would perhaps be a safeguard but we know now that we cannot assume this to be so since we know that animal tumors can survive freezing for long periods and remain viable.

However, as Dr. Higinbotham pointed out, we believe there is a safety factor in the inability of human cancer to grow in one patient after removal from another. We have been unable to find anything in the literature that would indicate that transplantation of cancer from one patient to another has ever been noted. Unfortunately, to prove this on the human would be very difficult and would involve a long follow-up. I have dis-

cussed the possibility of human experiments with others and we do not believe it is practical at the present time. Therefore, for the time being we consider it to be safe, with proper precautions, to use bank bone taken from the ribs of patients who have had exploratory thoracotomies for mediastinal or lung tumor. We would prefer to discard those specimens of ribs which have been reported by the pathologist as definitely showing malignant tumor. Unfortunately thoracotomies for benign conditions are not done frequently enough in our hospital to afford us a sufficient supply of bank bone.

Someone suggested, "After removing the bone from the jar in which it was refrigerated, why not drop it in the instrument sterilizer and boil it for a few minutes just before using it?" We have not been anxious to use boiled bone, believing that it would not behave in the host as favorably as refrigerated bone or as fresh bone directly from the patient or the donor.

JOHN C. A. GERSTER (New York, N. Y.): I might suggest to Dr. Coley and Dr. Higinbotham that as there is a vast amount of thoracoplasty for tuberculosis being done and all those bones are being thrown away by the operators, these bones might be contributed to their bone bank. Just the way the corneal transplants are gathered from various places, so, in the case of bone, this might be done. I am sure the thoracic surgery service at the Lenox Hill Hospital would be glad to furnish a generous supply of such bone. The speakers would not have to worry about potential cancer if they did not mind using uninfected bones from tuberculous chests.

NORMAN L. HIGINBOTHAM (closing): I would like to thank Dr. Gerster for his very kind offer of tuberculous bones but I think Dr. Coley and I would both prefer to use bones from cancer patients. I believe cancer would be less transplantable than tuberculosis would. We are reasonably sure, although we can not prove it, that cancer cannot be transplanted from one human to another. I think tuberculosis could, very readily, and if these patients are operated upon for tuberculosis, I think they would be more apt to carry the hazard of transplantation than cancerous bone.



# THE MANAGEMENT OF CHRONIC SUPPURATIVE OSTEOMYELITIS OF THE FEMUR\*

G. EDMUND HAGGART, M.D. AND MELVIN T. HURLEY, M.D.

*Boston, Massachusetts*

SINCE the antibiotics have become available, notably penicillin, the treatment of chronic suppurative osteomyelitis has been changed from that of the technics previously employed. However, in patients with infections of long duration, particularly in those individuals who present involvement of the femur, we believe that it is essential to combine surgery with drug therapy in order to achieve a satisfactory result.

It is the purpose of this paper to present our experience and the results obtained in the treatment of long-standing chronic osteomyelitis of the femur in twenty-one consecutive patients. This is admittedly a small series; nevertheless, these patients illustrate the severe systemic reaction consequent upon such an infection together with the details of management which with one exception have saved the extremity and led to complete healing.

## PROCEDURE

A detailed and thorough history is taken and a physical examination carried out including complete blood counts, urinalysis and sedimentation rates as well as blood grouping. In those individuals with a draining sinus present bacteriologic investigation is done including sensitivity tests on the dominant organism with penicillin and streptomycin.

The next and a most important step in this preliminary study is an injection of diodrast into the sinus tract performed in the Department of Radiology where stereoscopic anteroposterior and lateral views of the involved area are obtained. (Fig. 1a to d.) Since one of the major objectives at surgery is excision of the sinus tract, it is most important in planning the operation that as accurate an idea as possible is obtained of the extent of the tract as well as illustrating the particular area of bone involved. So strongly do we believe on this score that three patients (not included in this series) admitted during the past year with a sinus tract recently healed were repeatedly observed until

the sinus again opened and this injection could be carried out.

Before surgery the patient is given whole blood transfusions to restore a more normal blood picture as without exception all patients in this series exhibited a degree of anemia sometimes quite pronounced. Furthermore, administration of the selected antibiotics as determined by the sensitivity test is begun forty-eight hours in advance of surgery and continued thereafter as seems indicated. In this series the hemolytic staphylococcus aureus was isolated in 34 per cent and the non-hemolytic staphylococcus in 46 per cent of the patients, hence penicillin was the agent of choice. The dosage averaged 3,000,000 units every twenty-four hours. Later, for the comfort of the patient and with satisfactory progress, it was shifted to 600,000 units of crystacillin given in two equal doses over the same interval.

## OPERATION

Following appropriate preparation the first step is to inject the sinus tract with methylene blue under considerable pressure. In the presence of multiple sinuses every effort is made to block their exits temporarily so that the entire tract can be thoroughly impregnated with the dye. This procedure has been of great assistance in accurately delineating the walls of the tract so that all of it may be excised.

A direct lateral approach to the femur, splitting the fibers of the vastus lateralis just above the lateral intermuscular septum, has been found most satisfactory. In those instances when the bone infection was confined to the distal portion of the femoral shaft, the vastus lateralis was displaced anteriorly. There is initially considerable bleeding but this can be quickly checked by careful hemostasis; its effects are also combated by transfusions given during the procedure. We do not favor the anterolateral approach in these patients because of later limitation of knee joint motion due to adhesions of the quadriceps musculature

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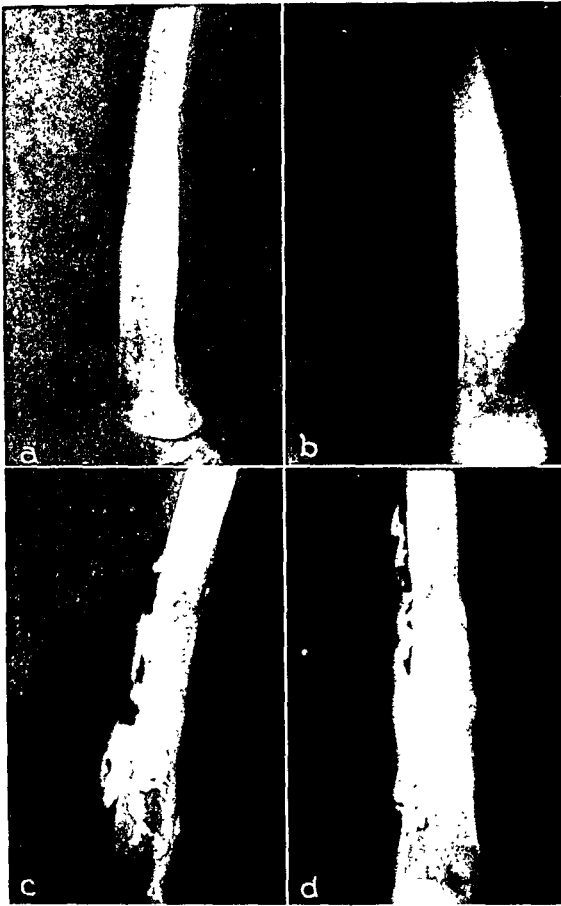


FIG. 1. Case E. G. Chronic suppurative osteomyelitis of eleven years' duration; *a* and *b*, admission roentgenograms; the oval defect in the bone is the result of previous surgery elsewhere; *c* and *d*, extent of sinus tract is shown following injection with diodrast.

to the shaft of the femur. Posterior exposure of the bone is not acceptable because of possible involvement of the sciatic nerve in the infection and scar as pointed out by Bosworth.<sup>1</sup> A tourniquet is not employed.

The only instances in which we have utilized a more anterior incision were in those patients with osteomyelitis of the proximal third of the femur when the dissection was carried down between the sartorius and tensor fascia femoris muscles.

Following removal of the sinus tract the femur is carefully inspected and the findings checked with those on the x-ray film. Series of drill holes are made in the cortex to outline the area of involved bone which is then removed by connecting the drill holes with an oblique osteotome and a motor saw. It is not only necessary to remove all of the obviously infected bone and sequestra both within and



FIG. 2. Case E. G., *a* and *b*, postoperative roentgenograms illustrating the amount of infected bone removed; the previous operative defect shown in the anteroposterior view was not disturbed as it was simply a window in the bone with no immediately adjacent active infection.

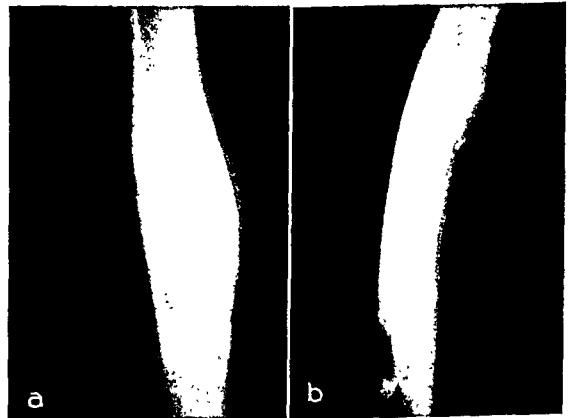


FIG. 3. Case E. G., *a* and *b*, four years five months after surgery; patient asymptomatic; note regeneration of bone.

outside of the marrow cavity but also sufficient bone is cut away to make certain that no "pooling" may form after the wound is closed. (Fig. 2*a* and *b*.) In other words it is essential to excise part of the lateral and posterior cortex in the area and in some instances may be necessary to take out a portion of the medial cortex.

After thorough cleansing of the wound with saline irrigations anteroposterior and lateral portable x-rays are taken to determine whether an adequate excision of infected bone has been performed and also to make certain that there are no bone fragments left in the wound. The latter is particularly prone to occur because the bone in question is so sclerotic that it splinters and small fragments of bone may be overlooked



FIG. 4. Case R. T. D., *a* and *b*, admission roentgenograms with diodrast injection; osteomyelitis of five years' duration subsequent to a series of boils; multiple sinus tracts present.

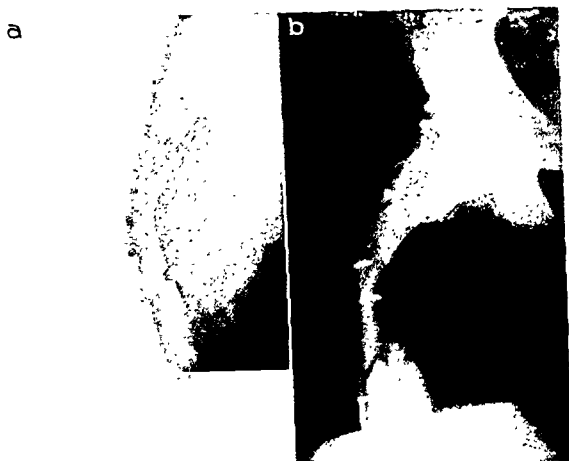


FIG. 5. Case R. T. D., *a*, portable roentgenogram taken in operating room illustrating the large amount of bone that had to be removed so that the patient sustained a fracture which was thereupon plated; *b*, short proximal screws penetrate all that remained of the cortex. In the preparation of the x-rays the films were inadvertently reversed.)

in the soft tissues unless check-up x-rays are taken.

Following the final review of the entire field for bleeding points the wound is firmly closed in layers without drains. If a large operative defect in the femur has been created, the patient is initially placed in a single plaster hip spica, otherwise in suspension and adhesive traction applied to the skin of the lower leg.

Muscle transplants to fill in the bone defect as suggested by Starr<sup>2</sup> and Prigge,<sup>3</sup> have not



FIG. 6. Case R. T. D., *a* and *b*, seven months following surgery the patient refractured the femur in an automobile accident; note the previous fracture healed and the extensive regeneration of bone. The fracture line is not visible in lateral projection.

been utilized in this series because our experience with this procedure in patients treated prior to this group was not particularly successful. No attempt has been made to pack the defect in the femoral shaft with bone chips. This may be an additional technic of value but in the first patients of this series it would have been necessary to obtain bone from another site in the same patient. In consideration of the magnitude of the combined procedures this was considered ill-advised. Now with the aid of the bone bank such an additional step is more feasible. On the other hand our experience with the rate at which adults regenerate bone (Fig. 3*a* and *b*) has been such that at present we are not utilizing the bone bank facilities for these patients.

#### COMPLICATIONS

As shown in Figures 4 and 5*a* and *b*, the shaft of the femur is weakened by wide removal of bone over an extensively involved area. This particular patient suffered a fracture of the proximal shaft at the time of surgery which was thereupon plated (Fig. 5*a* and *b*) and the wound healed by first intention. Seven months later he was asymptomatic but in an automobile accident he refractured the femur in an area just above the previous fracture which was healed; the fragments fortunately were held by the upper end of the plate. (Fig. 6*a* and *b*.) From this the patient also recovered without incident and despite the additional trauma he has not at any time exhibited signs of recurrent osteomyelitis during the twenty-eight-month period of follow-up. (Fig. 7*a* and *b*.)

One other patient who healed by first intention sustained a fracture through the saucerized area of the distal femoral shaft twenty-two months after surgery as the result of a severe





FIG. 7. Case R. T. D., *a* and *b*, three years four months following the operation; patient asymptomatic with normal range of hip and knee motion.



FIG. 8. Case R. S., *a*, first admission roentgenogram; note area of bone destruction about the region of the lesser trochanter; *b*, postoperative film; note bone removed in region of lesser trochanter.

fall. The x-rays then and since that time, thirty-nine months since his operation, have shown no further evidence of active osteomyelitis.

There have been no incidents of postoperative embolism or thrombosis. When the area of bone removal was adjacent to the region of the femoral condyles, there was a temporary loss of knee function but in every instance the preoperative range of motion was regained.

#### ANALYSIS OF END RESULTS

In this series of twenty-one consecutive cases of chronic suppurative osteomyelitis of the femur there were twelve males and nine females, with an average age of twenty-seven years for males and thirty-five years for females. Fifty-four per cent of the cases involved the right femur and the left femur was infected in 47 per cent. The average duration of symptoms in all cases was nine and a half years ranging from a maximum of twenty-eight years to a minimum of one year. Sixteen patients, 76 per cent, presented draining sinuses in the

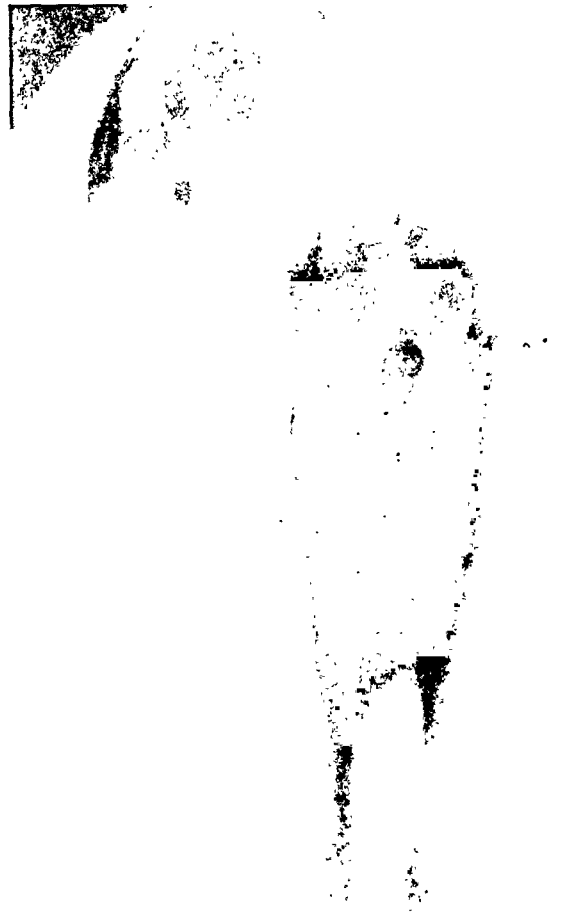


FIG. 9. Case R. S. Film on second admission; large abscess cavity of proximal femoral shaft is evident.

region of the involved bone. The disease was of hematogenous origin in all instances except in three patients. In one infection followed a gunshot wound; in the remaining two infection was the result of open reduction and internal fixation of fractures performed elsewhere.

Of the total series sixteen or 76 per cent healed by primary intention and have remained healed and symptom-free for an average period of 2.7 years. The longest follow-up on any one of these patients healing by first intention was nine years, the shortest eleven months.

The results in four patients as compared to those previously noted have been classified as good. All healed by first intention following surgery but developed subcutaneous abscesses in the scar from three to nine months after operation. In each instance these were localized processes. The x-ray revealed no evidence of active bone infection nor at the time the abscess was incised and drained, which was the treatment plus a ten-day course of penicillin, was

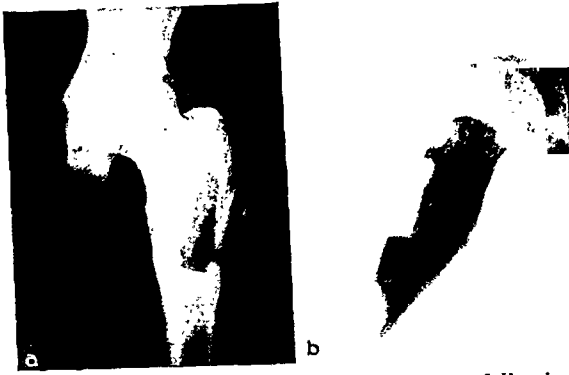


FIG. 10. Case R. S., *a* and *b*, roentgenograms following the second and definitive procedure.

there any evidence that the abscess communicated with the femur. Since incision and drainage in these four patients they have remained healed and have been asymptomatic for a period ranging from one year in the most recent case to six years in the longest follow-up.

In a fifth patient, a failure, delayed healing occurred but in one year's time the process again became very active; the sinuses reappeared and this patient eventually came to thigh amputation. Two years following this procedure he was asymptomatic and ambulatory with a well fitted prosthesis. It is our belief that in this instance the failure was the result of a combination of factors, viz., the patient was a sedentary, overweight male of forty-nine who gave a twenty-eight-year history of suppurative osteomyelitis of the left femur with multiple draining sinuses and repeated operations. When he was admitted to the hospital October 23, 1945, the anterolateral soft tissues of the thigh presented an almost board-like rigidity due to extensive scar formation. Among the organisms cultured was a persistent Freidlander's bacillus which became resistant to streptomycin. When the patient was first operated upon on November 13, 1945, this particular organism was found only at the time of surgery. Previous cultures of the sinuses had not revealed it. Streptomycin was then available in comparatively minimal amounts. We were fortunate in being able to obtain 1,000,000 units which in combination with penicillin and surgery led to complete closure of the sinus tract. The patient's general condition was then noted as satisfactory only to have a recurrence a year later.

#### CASE REPORT

The following case report illustrates the steps in the development of our present plan for the management of chronic suppurative osteo-  
*November, 1949*

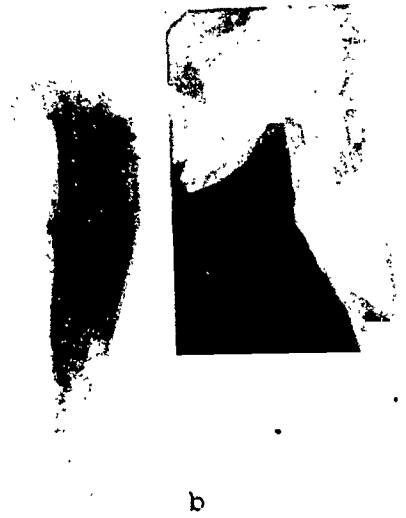


FIG. 11. Case R. S., *a* and *b*, four years ten months following the second operation; patient asymptomatic with normal hip and knee motion; note regeneration of bone.

myelitis of the femur. This patient was under treatment both before and after penicillin became available. In the first procedure the patient was given intensive sulfathiazole therapy while the surgery was not as radical as is now believed indicated.

R. S., a male student of eighteen, was first seen November 23, 1942, because of an acute suppurative osteomyelitis of the femur with large abscess formation in the proximal thigh and with an area of bone destruction about the lesser trochanter together with sclerosing osteitis of the proximal shaft of the femur. The patient stated the first symptoms occurred in September, 1941, following a severe blow on the upper left thigh while playing football. There was no soft part abrasion or wound. He was at that time given sulfonamide drugs, put in a cast for an interval and was thereafter completely asymptomatic for one year when a small abscess developed in the upper thigh and drained for a few days. After this he again felt well until one week before admission when another abscess appeared. For this he came under our supervision. (Fig. 8*a*.)

Following intensive sulfathiazole administration operation was performed November 27, 1942, when a very large subcutaneous abscess in the anterolateral left thigh was drained. From it a tract led to an area of bone destruction involving the lesser trochanter in which there was a cavity which contained a teaspoonful of pus. The walls of the abscess cavity, sinus tract and area of involved bone were excised and the wound healed by first intention. Figure 8*b* is a roentgenogram taken January 21, 1943, when the patient was ambulatory on crutches and progressively increasing activity.

This man thereafter remained well until August

20, 1943, when a small sinus developed in the lateral proximal left thigh from which he reported some slight initial discharge. However, when seen on the date noted there was none nor was there any evidence at that time of active bone infection. The sinus promptly closed and the patient then was asymptomatic until he was readmitted June 30, 1944, because a sinus had formed. At this time the x-rays (Fig. 9) revealed an abscess cavity in the proximal femoral shaft. Diodrast injection of the sinus showed the tract leading to the abscess and a shorter branch posterior to the femur. The report on cultures was again hemolytic *Staphylococcus aureus* and very sensitive to penicillin. Therefore, the patient was placed on intensive penicillin therapy.

At operation, July 17, 1944, the large bone abscess cavity was cleaned out and the adjacent infected bone widely excised. (Fig. 10a and b.) The wound healed by first intention and has remained healed and the patient asymptomatic up to his last visit May 6, 1949, four years and ten months after operation. At this time the x-rays (Fig. 11a and b) still exhibit persistent sclerosis of the femur but no evidence of active bone infection.

#### SUMMARY AND CONCLUSIONS

With a combination of antibiotic therapy and adequate surgery the treatment of chronic suppurative osteomyelitis of the femur now offers a more hopeful prognosis.

Accurate delineation followed by complete excision of the sinus tracts and thereafter thorough removal of infected bone are the significant procedures at operation.

The details of and end results obtained in the management of twenty-one consecutive patients with chronic suppurative osteomyelitis of the femur are presented.

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#### DISCUSSION

STEPHEN S. HUDACK (New York, N. Y.): I would like to congratulate Dr. Haggart on his courageous attempt at tackling an extremely complex and difficult problem. Dr. McLaughlin tells me that he has operated on a patient who had a cured osteomyelitis approximately at the age of five and operated at the age of fifty-four for osteomyelitis, with a quiescent period in between. I, myself, have seen one with approximately a forty-two-year span.

Three months ago I operated on a boy who had

been operated on by the elder Albee and more recently by someone else for a cup arthroplasty, with fused hips having had a fifteen-year history of bilateral chronic osteomyelitis. The dominant factor there was a hemolytic *staphylococcus aureus*. When the cup was removed, there was a large posterior shelf of bone from which two pockets culturing bacteria were excised. This had existed for a period of fifteen years, as I said, having been operated successfully twice with primary closure of the operative wounds.

I would really like to know in some of this diseased bone what lets Dr. Haggart decide where he stops cutting the diseased bone? At the present sitting I have no way of knowing where the diseased bone or the bacterial invasion of the haversian canals, for instance, actually ceases. I wish he would tell us or give us a guiding sign.

G. EDMUND HAGGART (closing): In the first place I would emphasize that, obviously, I do not know if these people will all continue well. You saw those end results. The patients still have bone sclerosis. All I know is that they have gone this far and it is a fairly good follow-up to date. We aim to keep after them. We hope they will continue asymptomatic; they have done better on this therapy than any other type we have encountered.

As to where you stop cutting, etc., one of the things that has helped us the most has been the delineation of the sinus tract. When present it has led to the bone and that has been, so to speak, the locus from which we began and around which we planned the extent of the excision. With the lateral and some of the posterior cortex then removed, you clean out the medullary portion of the bone trying always to save at least the anterior aspect. Sometimes you cannot. It has been our experience that with the area of bone infection well exposed, you can follow a more or less definite abscess cavity. You cannot see this in the x-ray but it really exists up to a point where it is blocked off in the shaft. Twice in my experience with this group we have come into what appeared to be normal marrow and I was considerably disturbed because I thought, "Well, that means the infection goes right on up the shaft." Fortunately, it did not nor has there been any evidence so far of doing so. In those two cases one has been followed five and the other four years and some months.

I think the answer to Dr. Hudack's question is in summary that the abscess cavity within the bone, having excised the walls and removed the sequestra, etc., has been the factor which has delineated the extent of surgery and stopped us from excising any more bone. You will note, finally, in that one illustration, as I told you, there was an opening like a window (and that is exactly what it was in the bone) from previous surgery. There was no evidence of infected bone around it that I could see and, therefore, we left it alone and did not go into that area.

# MAJOR AMPUTATIONS OF THE EXTREMITIES DUE TO TRAUMA

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THIS article is an analysis of seventy-six major amputations performed on sixty-seven individuals. These cases were assembled through the years 1937 to 1948 inclusive and include both civilian and industrial traumas. Only those cases in which all of

*Evaluation for Surgery.* The patient's history, age, general physical condition and all important factors are taken into account. In a case in which the extremities were so badly crushed that there was no hope of survival, preparations were made in surgery to remove the extremity

TABLE 1  
AMPUTATIONS (SIXTY-SEVEN CASES)

	Number		Per cent		Deaths (Eight Cases)			
	Single	Double	Single	Double	Single		Double	
					No.	Per cent	No.	Per cent
Arm.....	10	..	14.92	.....	2	2.99		
Forearm.....	5	..	7.46					
Wrist and hand.....	3	..	4.49					
Thigh .....	12	5	17.91	7.46	2	2.99	2	2.99
Leg.....	23	4	34.34	5.96	1	1.49	1	1.49
Ankle and foot..	5	..	7.46					
	58	9	86.58	13.42	5	7.47	3	4.48
	67		100.00%		11.95%			

the phalanges were amputated are included. (Table 1.)

### PREOPERATIVE PROCEDURE

*First Aid Treatment.* First aid was available in many instances by people who had been instructed in first aid. The injured were allowed to lie within a few feet of where they were hurt. Tourniquets, stretchers and blankets were available. Doctor and ambulance were at the scene of the injury within eight to ten minutes. Morphine sulphate was administered for pain. After the doctor arrived the injured person was prepared for transportation where the tourniquets were re-examined and blood plasma was started if indicated. The patient was then transferred to a standard hospital a few minutes or a few miles away.

as soon as the patient had responded from shock and loss of blood. Blood plasma, whole blood and antibiotics were readily available. Large quantities of blood plasma and whole blood may be administered in a relatively short period of time. In most instances when other serious complicating injuries did not exist, the patient was in a satisfactory condition for guillotine or definitive surgery in from two to three hours.

*Preparation and Time of Amputation.* Erythrocyte and leukocyte blood counts and hemoglobin estimation were carried out as well as urinalysis. Portable x-ray machines showed the level and comminution of the bone fragments. The circulation of the extremity distal to the point of injury was estimated. When any indication exists that there is a possibility of

saving any part of the injured extremity, surgery is postponed until there is no question of doubt that the amputation is necessary. The injured extremity may be suspended in a well padded splint and, in some instances, extension is advisable. It is surprising how many badly crushed extremities will respond to gentle care.

*Anesthesia.* Working in several hospitals makes a variety of anesthetics necessary. In one instance a nurse anesthetist is very adept at inhalation anesthesia. In another hospital intravenous pentothal and inhalation oxygen is the anesthetic of choice. At a third hospital low spinal anesthesia reinforced with a minimum of pentothal sodium intravenously is the anesthetic preferred. There is no question of doubt that the graduate doctor who has specialized in anesthesia has available many methods of anesthesia to the best interests of the critically injured patient requiring amputation.

*Determination of Amputation Level.* Guillo-tine amputation when necessary is carried out at the lowest level of bone viability. This is sometimes ambiguous when extensive avulsion of the skin has occurred. There is a limit to which viable skin can be stretched from adjacent parts.

#### EXTREMITIES INVOLVED

*Foot.* Basic facts about thousands of amputations in war and peace are available in the literature. A difference of opinion does exist. The British, for instance, want no part of a Chopart amputation while the Canadians report excellent results in quite a series of cases. The Americans believe that Chopart's amputation has merit and will explore it further. While amputation through the foot has been looked upon with disfavor by most authors, it is interesting to note the divergence of opinions. Kirk<sup>4</sup> in 1944 expressed himself about the equinus deformity and tilting of the os calcis which occurs because of the unopposed pull of the tendo-achilles. McKeever<sup>5</sup> in 1946 stated that the Chopart amputation was doomed to failure and should not be done if the muscles in front of the leg had lost their attachment to the stump of the foot. McKeever<sup>6</sup> in 1947 was of the opinion that if muscle balance was lost in the foot stump, progressive deformity usually resulted which ultimately produced a fixed deformity. A fixed deformity in turn

makes weight-bearing painful and may make it impossible to wear a shoe.

In the normal foot the flexion and extension of the foot is perfectly balanced in association with the mutual balanced muscular cooperation of pronation and supination.

In trauma of the foot when amputation is indicated, a long plantar flap is necessary. Kirk believes that the highest permissible level of amputation of the foot is distal to the bases of the metatarsals. This is indeed an ideal situation but much can be done, however, with considerably less. McKeever,<sup>6</sup> furthermore, is pessimistic about amputations proximal to the bases of the metatarsals because in his experience inversion deformity of the foot along with calluses on the outer anterior side of the stump and ultimate equinovarus deformity has resulted. In arteriosclerotic gangrene, diabetic gangrene, thrombosis, embolism, neoplasm and thrombo-angiitis obliterans; other factors play complicating roles. In this series of cases these conditions did not primarily exist.

Crego and McCarroll,<sup>2</sup> Scuderi<sup>7</sup> and other authors present series of cases of poliomyelitis and irreparable nerve injury in which extremities have been stabilized for the correction of deformity. Undoubtedly abnormal muscle pull is the most common underlying factor of the deformity. When flexion-extension and pronation-supination groups of normal muscles are available, it seems that we should be able to stabilize the normal, healthy leg muscles that have temporarily lost their normal relations and attachments. Tendons may be repaired and transplanted. The exact procedure to be used depends on the individual case. The individual power of muscles will change after re-attachment. Corrective re-stabilization of the foot through a full range of motion is not usual in most instances because of the change in leverage. (Fig. 1.)

*Leg.* When a suitable weight-bearing extremity cannot be produced in the foot, the most successful level of amputation in the leg is at the level where the muscle bellies transform themselves into tendons. The average length of tibia useful for prosthesis varies from 5 to 7 inches. The length of 6 inches is about the junction between the middle and upper third of the leg. The fibula is always cut from 1 to 2 inches shorter than the tibia. When the length of the fibula is less than 4 inches, less complications will follow if the fibula is entirely



FIG. 1. Lateral x-ray showing distal tarsal amputation.



FIG. 2. View of partially amputated foot of x-ray shown in Figure 1; motion normal.

removed. Any length of tibia saved between 7 inches and 2 inches is to the best interest of the patient, with respect to future prosthesis. Even this short stump is most useful in the normal use of the knee even though the prosthesis must be attached above the knee. (Figs. 2, 3 and 4.)

*Thigh.* A level about 4 inches above the distal weight-bearing surface of the femur is the amputation of choice. This level must be associated with a stump that is conical and subsequently properly shrunk; otherwise the knee mechanism of the prosthesis makes the thigh longer than the opposite normal thigh. From the supracondylar level to the hip joint every part of an inch of femur and adjacent tissues are invaluable for use in prosthesis.

*Hand.* The most suitable amputation in the upper extremities proximal to the metacarpals is to leave all of the carpals. The lower end of the radius and ulna without the carpals has a rather bulky distal extremity and does not take to prosthesis kindly. The distal radius-ulna level is satisfactory for use in holding objects firmly and in assisting with any processes carried out with the opposite hand.

*Forearm.* If amputation must be carried out

through the forearm, a most satisfactory level is the junction of the middle and lower thirds. Any length which must be sacrificed proximal to this level has several disadvantages, the most important of which are: (1) there is less bone to act as a lever in the prosthesis; (2) as the prosthesis approaches the elbow, it impinges on the normal range of elbow motion.

*Arm.* In amputations above the elbow the most satisfactory, useful stump is obtained when the humerus is sectioned from  $2\frac{1}{2}$  inches to 5 inches above the distal surface of the medial and lateral epicondyles. The removal of only the distal  $2\frac{1}{2}$  inches of supracondylar area does not give adequate space to attach the elbow mechanism. When the distal 5 inches of humerus has been amputated, the triangular widening of the shaft has been entirely eliminated. All bone sacrificed proximal to 3 inches of supracondylar humerus is uncalled for unless absolutely necessary.

#### TECHNIC OF AMPUTATION

Mechanical tourniquets are removed and the brachial or femoral artery is compressed by an assistant proximal to the operative field in the axilla or groin. A ten-minute soap and water scrub is carried out in the operative field. The level of bone length is measured and marked on the skin. An incision is made through the skin, subcutaneous tissues and aponeurosis of the muscles perpendicular to the skin surface. The skin, subcutaneous tissues and muscular aponeurosis is allowed to retract back in one piece, a distance equivalent to a quarter of the



FIG. 3. Lateral x-ray of mid-tarsal amputation.

circumference of the leg at the level of amputation. The muscles are cut circularly around the stump for a third of their thickness and allowed to retract. A second cut is made at the new level through another third of the muscle depth and again allowed to retract. At the final third level the muscles and tissues are cut entirely down to the bone. The periosteum is cleanly cut at bone length with a scalpel, the muscles are retracted and the bone cut off with a saw. The sharp edges of the bone are gently rounded off with a fine file.

The blood vessels are dissected out, clamped, cut and doubly tied 1 inch proximal to the bone end.

The nerve is gently isolated, tissues retracted from it and then cut transversely with a sharp scalpel 2 inches short of the bone length.

A medial and lateral *v* is removed from the skin, subcutaneous tissues and muscle aponeurosis. A Penrose drain is placed down to the bone, coming out laterally. The muscle aponeurosis alone is joined over the bone end with interrupted sutures of No. 0 chromic catgut. The skin is closed with continuous locked dermal sutures.

**Nerves.** Phantom limb, painful or painless, and neuromas are complications which sometimes follow amputations. Phantom limb without pain has been noted but other than the eerie sensations and cramped fingers or toes



FIG. 4. Side view of mid-tarsal amputated foot shown in Figure 3.

complained of, there was nothing of any serious importance.

Local novocain has been injected into neuromas as a test to determine whether or not the painful symptoms could be obliterated. Novocain has been injected into the sympathetic and ganglions at different levels for the relief of numerous conditions. Gilcrest<sup>3</sup> stresses the value of interruption of the sympathetic nerve supply in post-traumatic osteoporosis. Investigative work is being carried on at the present time on these conditions.

The intravenous use of procaine has been tried in some of these painful and painless conditions and found to be encouraging. One case of causalgia was permanently relieved. Since pain is a subjective symptom, it is difficult to carry out experimental work. Intravenously the procaine works locally, regionally and centrally all at the same time. Previously it has not been possible to wipe out the central impressions of these conditions except with a general anesthetic or a hypnotic for periods of time with little or no chance of permanent relief.

*Method for Re-stabilizing the Foot.* The most important part of surgery through the foot is that part which has to do with the re-stabilization of the muscle balance. The gastrocnemius, soleus and plantaris are the group of muscles which initiate plantar flexion and are respon-

the remaining foot can be achieved when dorsal flexor tendons have been divided. The tibialis anterior, extensor hallucis longus, extensor digitorum longus and the peroneus tertius are the natural physiologic antagonists of the gastrocnemius-soleus group. These tendons

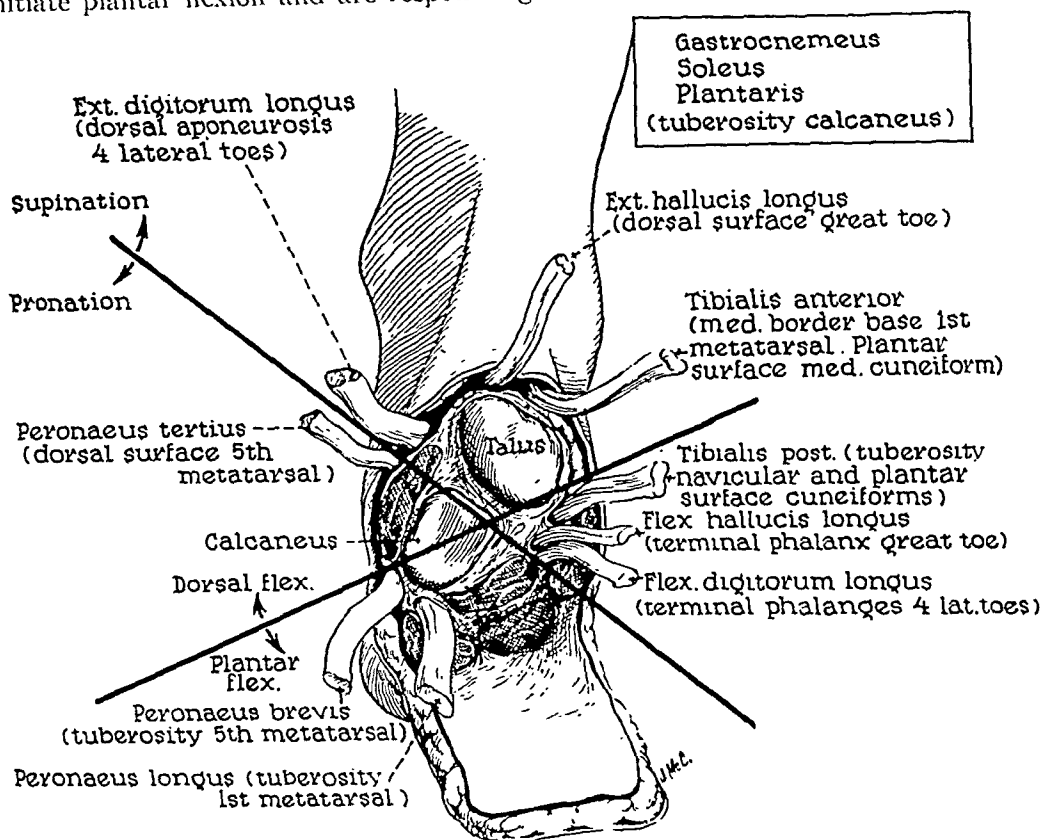


FIG. 5.

sible for the equinovarus deformity (if not corrected) after surgery. To do this surgery intelligently it is necessary to know the anatomy and normal physiology of the muscles individually and a basic knowledge of leverage. The number of tendons which have lost their normal insertions depend upon the level at which the foot is amputated. It is thus necessary to hold the foot in balance and re-attach the tendons so that the foot is in equilibrium postoperatively. It may be necessary to use a plaster splint postoperatively for a short time to hold foot in equilibrium.

Crego and McCarroll<sup>2</sup> and others have demonstrated that it is possible to re-stabilize the foot in infantile paralysis. Then, how much easier it should be for us when we have practically normal muscles to deal with. Series of cases in the hands of competent traumatic surgeons show that normal balance and use of

may be attached to bone or muscle aponeurosis in their line of leverage, or the whole group may be brought out and attached anteriorly. (Fig. 5.)

#### POSTOPERATIVE HOSPITAL CARE

A four-way adhesive extension is fixed to the skin of the stump and the straps attached to a square block of wood distal to the stump and dressings. A rope and sufficient weights over the end of the bed are attached to a block to overcome the ordinary retraction of superficial tissues.

The patient is returned to bed and allowed to move around at will, pain permitting. Sufficient sedation is given to control pain. Fluids are given postnausea and antibiotics as indicated. The drain is removed at the end of twenty-four to forty-eight hours depending on the amount of drainage. Passive and active



motion is stimulated at the end of twenty-four hours. When pain has subsided, the patient is allowed to sit up in bed, then in a chair and then up on crutches if it is a lower extremity. Weights are re-attached upon returning to bed. The sutures are removed in about seven to nine days followed by adhesive bridges. At the end of two weeks physiotherapy in the form of heat, massage and whirlpool bath is in order. When the tissues are no longer tender, tight elastic bandages are applied to help shrink the leg promptly.

#### VOCATIONAL REHABILITATION

A portion of these injured men had available to them a vocational rehabilitation service and took advantage of this service. The injured man's physical and mental ability, age, work-experience and background are taken into account. Thus the plan of training a particular individual is initiated. Some types of training that are available are civil, mechanical, chemical and aeronautical engineering, chemistry, business administration, teaching, journalism, pre-medical, law, music, accounting, laboratory technician, librarian, geology, watch and clock repair, shorthand, comptometry, typing, jewelry making, weaving, re-weaving, sewing, auto mechanics, welding, upholstery, shoe repair, dry cleaning and many others.

An analysis of the weekly income on the old job where the patients were injured and on the new job for which they had been rehabilitated shows that there are very few who are making

less than before they were injured. Most of the case histories show that their weekly income is considerably higher.

#### SUMMARY

1. Seventy-six amputations among sixty-seven individuals have been presented and discussed. There are nine individuals who had double amputations.

2. Methods of amputation are discussed in detail.

3. The intravenous use of procaine has been tried and found useful in some conditions affecting the sympathetic nervous system.

4. A method is suggested whereby all amputations through the foot can be stabilized at the time of surgery thus obviating deformity and painful and useless stumps.

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# SUCTION SOCKET PROSTHESIS FOR ABOVE-KNEE AMPUTEES

## INTERIM REPORT OF VETERANS ADMINISTRATION EXPERIMENTAL PROGRAM

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A PROSTHETIC device first patented by Dubois Parmelee of New York in 1863 has again attracted the attention of the medical profession. Originally utilized in conjunction with a pylon leg attaching the lower extremity prosthesis to the body by suction, Parmelee's idea had been tried in 1885 by Beacock and Sparham in Canada, in 1911 by Toles in California and in 1926 by Underwood in England. To improve the degree of suction the British added a helical groove in the socket lining. Furthermore they re-designed the appliance for use with a metal leg, the inserted bucket being fabricated of wood or papier-maché. In these earlier limbs the valves varied from a simple faucet to a one-way air escape valve. (Fig. 1.)

Following World War I about thirty suction sockets were fitted at Roehampton, England. Until recently case histories on these thirty patients had been lost and the suction socket prosthesis had been discarded. Then Oesterle of Ulm, Germany, advocated the use of the "Springer Vacuum leg" in 1933.<sup>1</sup> Furthermore, in Germany Felix believed the development of a satisfactory valve for the vacuum chamber was the item that popularized this method of prosthesis fixation in above-knee leg amputations.<sup>2</sup> Next Kirschner and Dittert reported a series of thirty-nine cases in 1944.<sup>3</sup> About the same time Hepp<sup>4</sup> described a contact type of prosthesis, a modification of the suction socket. Some military medical reports on suction sockets received in the United States immediately following V-E Day (May 8, 1945) prompted Major General Norman T. Kirk to appoint and dispatch to Europe in March, 1946, a committee of distinguished civilian and military engineers and orthopedic surgeons to investigate and report upon new orthopedic technics and appliances including the suction socket prosthesis. In 1946 this report was submitted to the National Research Council of the National Academy of Sciences for con-

sideration by The Committee on Artificial Limbs. In 1947 this Committee became known as the Advisory Committee on Artificial Limbs and was selected by the Veterans Administration, Army and Navy to coordinate all research projects pertaining to artificial limbs. It is a pleasure to report that the results of this Committee's activities are real. Many new devices have appeared such as the new arm prostheses designed by Fitch, by Hosmer and by the Northrop Aircraft Corporation. The wrist flexion unit and supinator and pronator device for below-elbow arm amputees represent recent developments.

The department of medicine and surgery of the Veterans Administration has been cooperating with this Committee. At this time among devices for artificial legs in the developmental stage are a new ankle joint incorporating horizontal rotation, several knee brake and lock mechanisms, both hydraulic and mechanical in operation and the suction socket for above-knee amputees. Recently Canty reported his experience at Mare Island Naval Hospital with the suction socket.<sup>5</sup>

Although results obtained on the suction socket prosthesis to this date are most promising it is deemed advisable not to consider them as conclusive. The source material reported here is contained in two reports received in May, 1949, by the Advisory Committee on Artificial Limbs. These reports were rendered by representatives of the limb manufacturing industry and by the Lower Extremity Committee, a technical subcommittee of the Advisory Committee on Artificial Limbs. It is believed that until a significant number of case histories can be compiled on those who have successfully worn the suction socket daily for an entire calendar year under a large variety of climatic conditions, it would be a mistake to claim complete success. Today there are very few surgeons or limb-fitters in this country who could claim to have seen or fitted more than

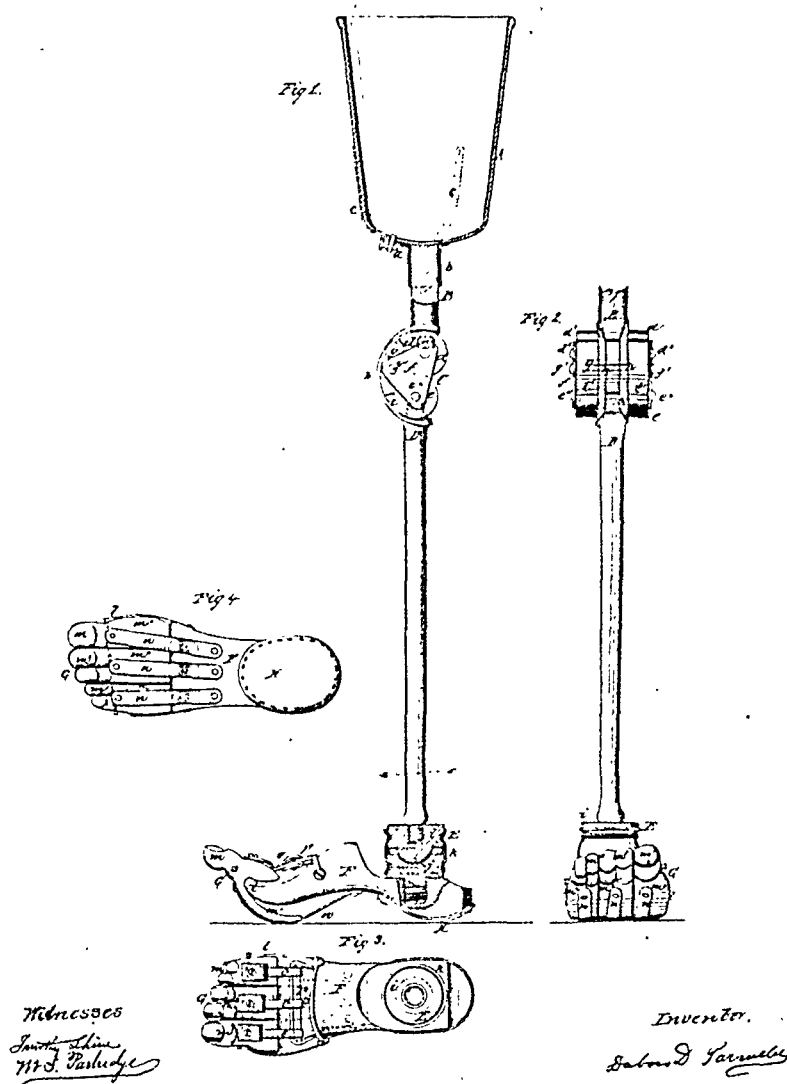


FIG. 1. The first known model of suction socket prosthesis. (U.S. Patent Office, No. 37,637.)

a handful of cases twelve months ago. Therefore, this report is to be considered as merely informational.

The statistics in Table 1 on above-knee suction socket experience have been compiled from responses to a questionnaire mailed to 159 members of The Orthopedic Appliance and Limb Manufacturers Association.

The Veterans Administration Experimental Suction Socket program which has been in operation less than two years involved first a training program for limb-fitters and surgeons. A total of twenty schools have been held in various parts of the country in which a total

of 200 limb-fitters and over 200 surgeons have been certified as qualified to fit the suction socket. Each one of this great number of fitters has been authorized to fit three suction socket limbs to veteran amputees. As of this date 495 suction socket limbs have been authorized to be fitted to above-knee veteran amputees. The most recent report (April 15, 1949) received from Professor Howard D. Eberhart, Chairman of the Lower Extremity Committee of the Advisory Committee on Artificial Limbs, records a total of 211 cases of which nine or 4.3 per cent are considered to be failures. (Table 11.) The geographic distribution of these

veterans is widespread involving all degrees of climatic variation.

The causes of the nine failures in the 211 cases reported are tabulated in Table III.

A group of twenty-nine patients exists still alternating in the use of the suction socket and

TABLE I\*

Number of sockets fitted to above-knee amputees.....	1,232
Men.....	1,023
Women.....	164
Children.....	45
Number of complete failures .....	50 (4 per cent)
* From Report of Preliminary Results, OALMA, May 4, 1949.	

the original conventional limb for reasons listed in Table IV.

It is only reasonable to adjudicate these results by the length of time that the suction socket has been worn. It must be emphasized that in this group of patients in the experi-

TABLE II\*

BRANCH VETERANS ADMINISTRATION OFFICE  
DISTRIBUTION OF RESULTS

Branch No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Wearing routinely.....	0	7	13	7	10	14	8	9	14	4	18	60	9	173
Alternating.....	0	0	1	4	5	1	0	4	4	0	0	10	0	29
Failures.....	0	1	1	0	2	1	2	0	2	0	0	0	0	9
Total.....	0	8	15	11	17	16	10	13	20	4	18	70	9	211

\* Report of Subcommittee, ACAL, April 15, 1949.

mental program 123 or 58 per cent have been wearing the suction socket four months or less and that in this group lie 75 per cent alternating between the use of the suction socket and conventional limb.

Table V illustrates the time interval in those cases in which a suction socket type of prosthesis was used. Inasmuch as only three patients in this series have been wearing the prosthesis successfully for ten months, one may readily comprehend the fact that unqualified approval of this device must be deferred.

To judge these results in the Veterans Administration Experimental Program as good is reasonable. Recalling that most fitters have been authorized to fit only three veterans and realizing that experience in pulling a suction socket is limited in most areas of the country, one might conclude that this report represents a fair measure of success. Moreover it is of importance to point out that successful fitting depends upon a change in the pattern and

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shape of the socket from the earlier design. Furthermore for the first six months the wearer must report at regular intervals for adjustments. Inasmuch as the stump becomes an active and functioning part of the amputee, stump changes occur. The usual adipose and

TABLE III\*

REASONS FOR FAILURES (NINE CASES)

Non-cooperation, gave up during initial fitting.....	3
Poor fit and alignment.....	2
Medical contraindications:	
Cyst or abscess on adductor roll remaining from using old leg.....	2
Insecurity (television actor gave up after five months' trial).....	1
Loss of suction (mechanic lost suction when lifting motor from chassis).....	1
Total.....	9
* Report of Subcommittee, ACAL, April 15, 1949.	

flabby stump loses its fat tissue and develops more normal musculature. During this period of change the surgeon, amputee and limb-fitter must be particularly conscious of the necessity for adequate follow-up.

TABLE IV\*

REASONS FOR ALTERNATING WEAR (TWENTY-NINE CASES)

New cases, increasing time on suction socket gradually.....	9
Insecurity on leg, loss of suction, bad alignment...	7
No time for proper adjustment, long working hours.	6
Replaced old socket, not yet adjusted to new one..	3
Wears, except at work.....	2
Excessive edema and perspiration.....	1
Insecurity on leg, bilateral amputee.....	1
Total.....	29
* Report of Subcommittee, ACAL, April 15, 1949.	

At first these sockets were usually fitted too tightly. The degree of suction required is only  $1\frac{1}{2}$  pounds per square inch negative pressure which during the stance phase of walking will change to  $1\frac{1}{2}$  pounds per square inch positive.

TABLE V\*

LENGTH OF TIME ON SUCTION SOCKET

Months	0	1	2	3	4	5	6	7	8	9	10	Total
Wearing routinely.....	0	15	23	31	25	15	16	20	21	4	3	173
Alternating†.....	0	4	8	5	5	1	5	1	...	...	...	29
Failures†.....	3	2	...	1	1	1	...	1	...	...	...	9
Sub-total.....	3	21	31	37	31	17	21	22	21	4	3	211
Cumulative total.....	3	24	55	92	123	140	161	183	204	208	211	211

\* Report of Subcommittee, ACAL, April 15, 1949.

† Months since initial fitting date rather than time on suction socket.

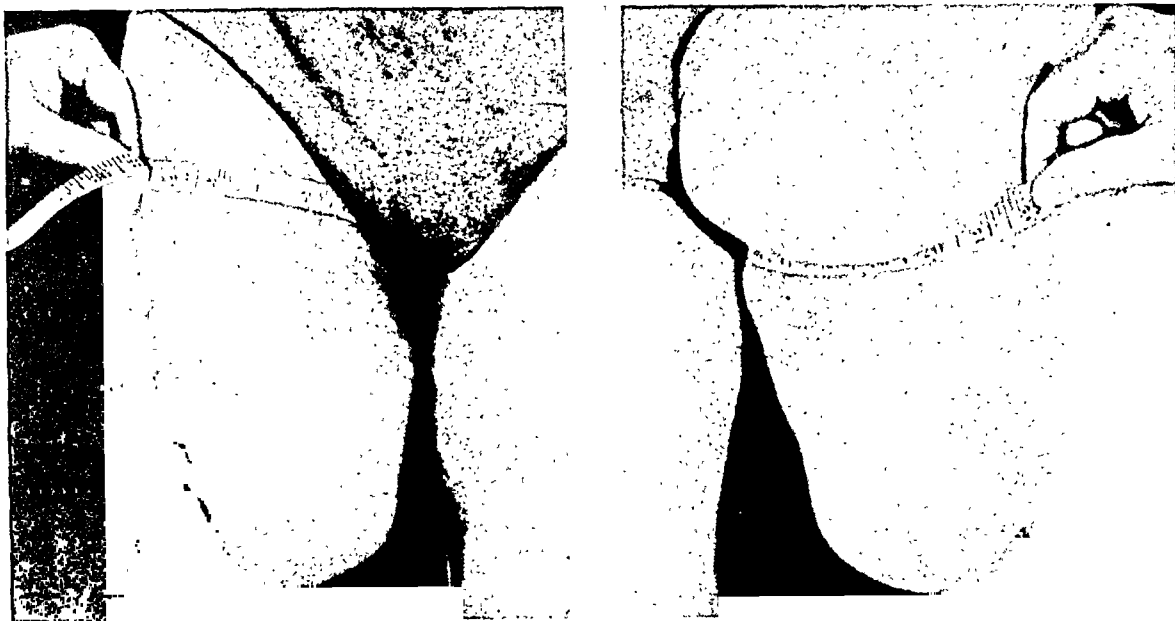


FIG. 2. Perimeter measurement for determining pattern size.<sup>6</sup>

An adequate air-escape valve has been designed so that these pressures are maintained consistently. It is perhaps erroneously termed a suction socket; the degree of suction is minimal. Suction alone holds the artificial limb when

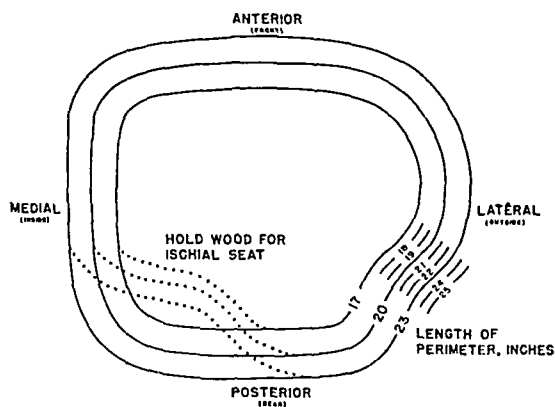


FIG. 3. Cross-section pattern at ischial seat level.<sup>6</sup>

the stump is relaxed while during actual walking the holding force is better described as even contact of the stump with the socket wall. The patient by contracting his remaining muscles in the stump can prevent its forceful withdrawal.

The modification in the shape of the suction socket pattern from the original design can be explained as the result of experience gained. It would be well to list the main changes as follows: (1) reduction in size of the ischial seat; in about 5 per cent of the cases fitted the ischial

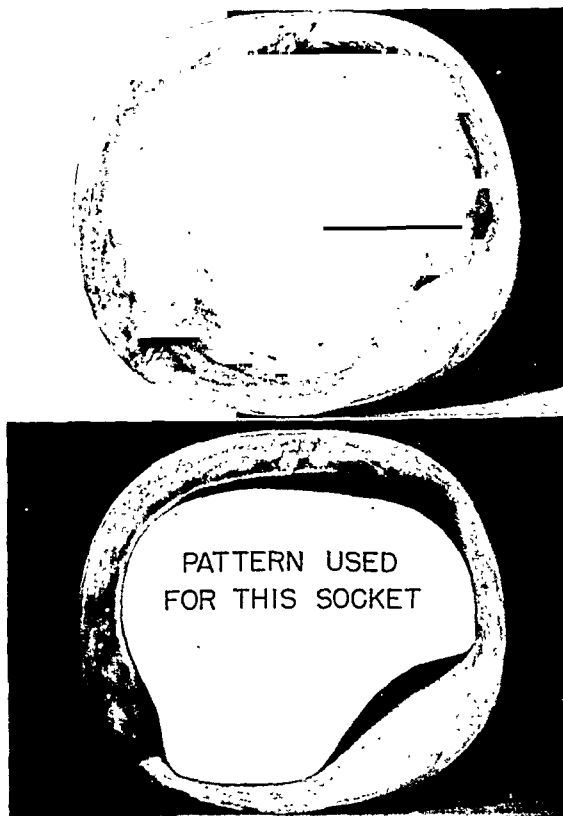


FIG. 4. Deviation from pattern of a typical suction socket.<sup>6</sup>

seat may be eliminated (indicated if a large and powerful gluteal muscle bundle is present); (2) properly shaped posterior surface of the

thigh making the back of the socket thinner and flatter, sometimes utilizing a soft back; (3) "easing" the fit on the walls of the socket all around below the level of the brim; (4) greater emphasis in proper alignment of the entire limb.

The main advantages in this suction socket

improved control and position sense. In addition the wearing of a stump sock is no longer necessary.

There is not space to describe the details of fabrication of this type of socket. Suffice it to state that a willow block is carved to form-fit

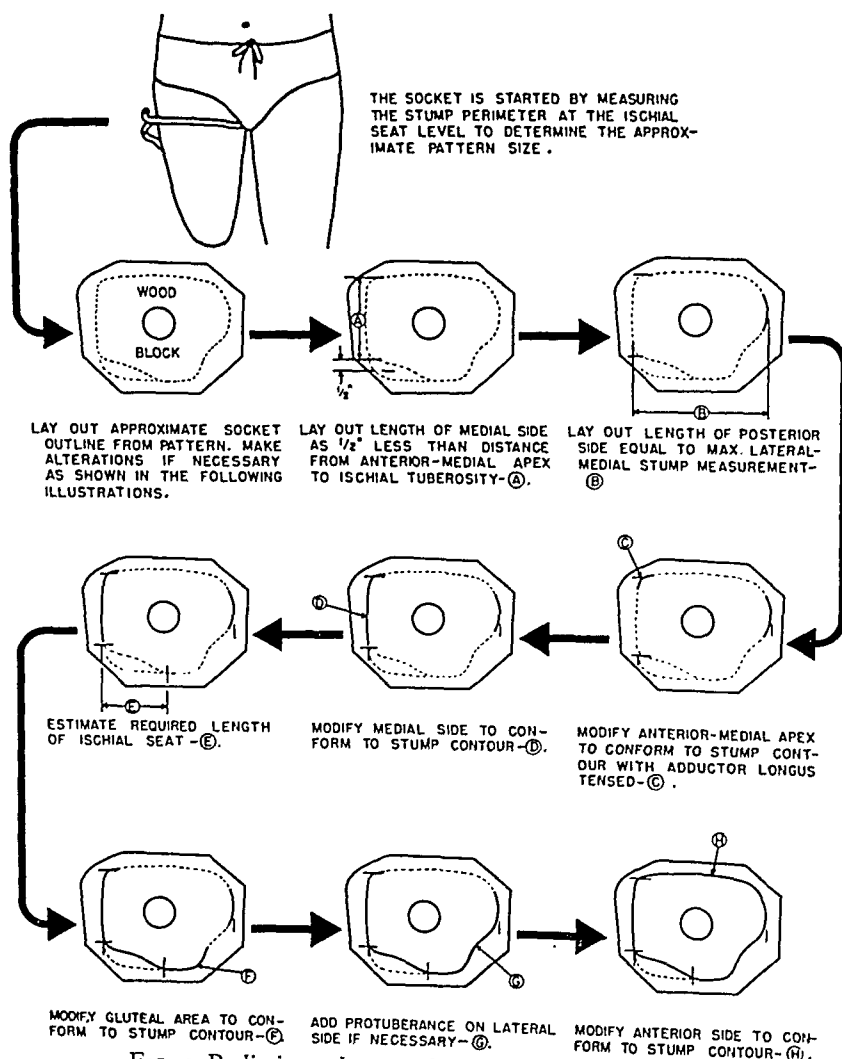


FIG. 5. Preliminary layout of the suction socket outline.<sup>6</sup>

type prosthesis are: (1) providing the above-knee amputee with a naturally functioning hip joint whereby his remaining muscles in the stump and about the hip resume physiologic balance resulting in better coordination; and (2) abolishing the suspension straps or pelvic belt with hinge. Suspension by a pelvic belt and a metal hinge in the conventional leg prevents necessary rotation in proper walking and has resulted in a high degree of belt breakage. On the other hand the amputees claim that suction socket type prosthesis feels as if it were a constituent part of the stump, resulting in

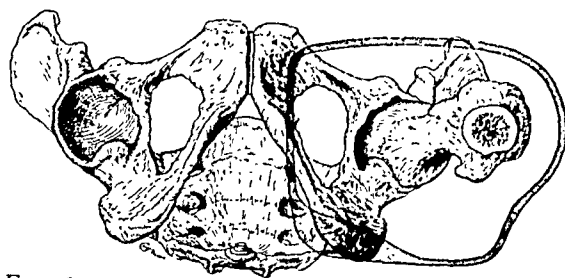


FIG. 6. Relation of the bony pelvis to the suction socket at the ischial seat level as viewed from below.<sup>6</sup>

the stump. An air-escape valve is inserted into the lower portion and over the lower end of the

block a plywood cover with an air seal is glued. This socket is then attached to the usual knee block, knee bolt and lower assembly. Those interested in the details of construction are referred to the third edition of the brochure,

with impaired circulation, capillary fragility in the stump, short or long stump or overweight individuals. Of course, the surgeon should accept only the most favorable cases at the start. However, by proper fitting experienced sur-

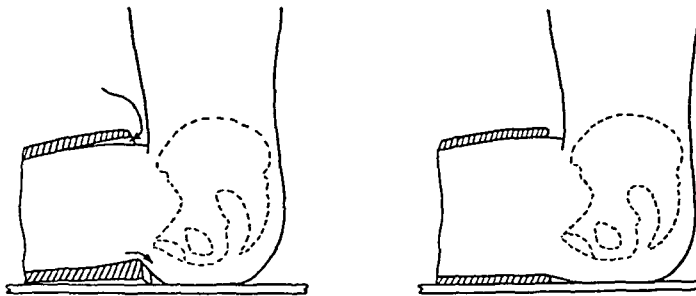
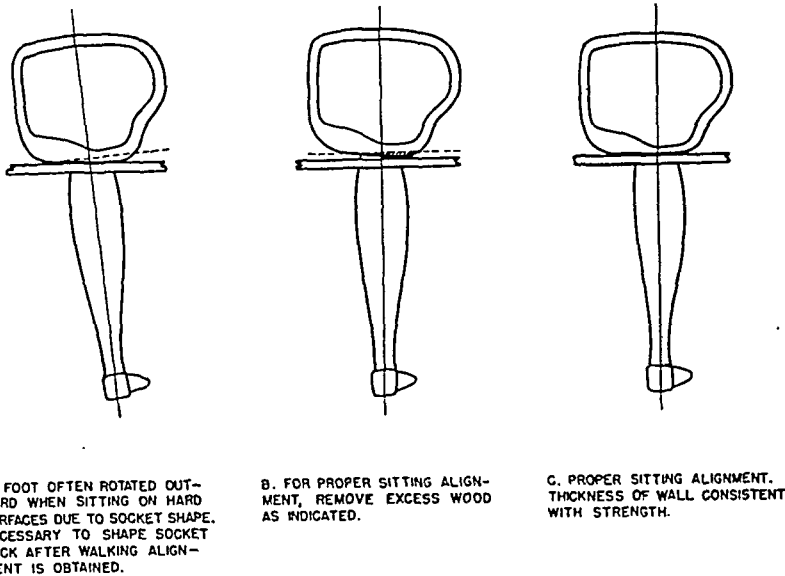


FIG. 7. Shape of the socket back and alignment of the leg in relation to sitting comfort.<sup>6</sup>

"The Suction Socket Above-Knee Artificial Leg."<sup>6</sup> (Figs. 2 to 6).\*

Many surgeons have been fearful of fitting stumps to this prosthesis because of associated injuries of the opposite leg, a bilateral above-knee amputee, deep or adherent scars below the top level of the socket, spurs or bone masses at the lower end of the stump, arterial disease

geons and limb-fitters have fitted stumps of less than three inches (crotch measurement). (Figs. 7 to 10.) Moreover, Gritti-Stokes end-bearing stumps tolerate this prosthesis well if the lower end of the socket is padded with felt. Sometimes, however, long weight-bearing stumps require a lowering of the knee bolt and shortening of the shank.

Specific contraindications exist. Perhaps the most important of these pertain to the psychologic attitude of the patient. It is much easier

\* Figures 2 to 10 are reproduced through the courtesy of Prosthetic Devices Research Project, University of California.

to satisfy a prosthesis wearer with a suction socket if the first leg fitted is of this type. All patients selected for this suction socket must be screened. The emotional, negativistic type of amputee should never be changed from a

lished meet one morning a week under the guidance of an orthopedic consultant. In these clinics will be fitted not only the suction socket wearer but also all orthopedic shoe, brace and prosthesis wearers. As outlets for the field

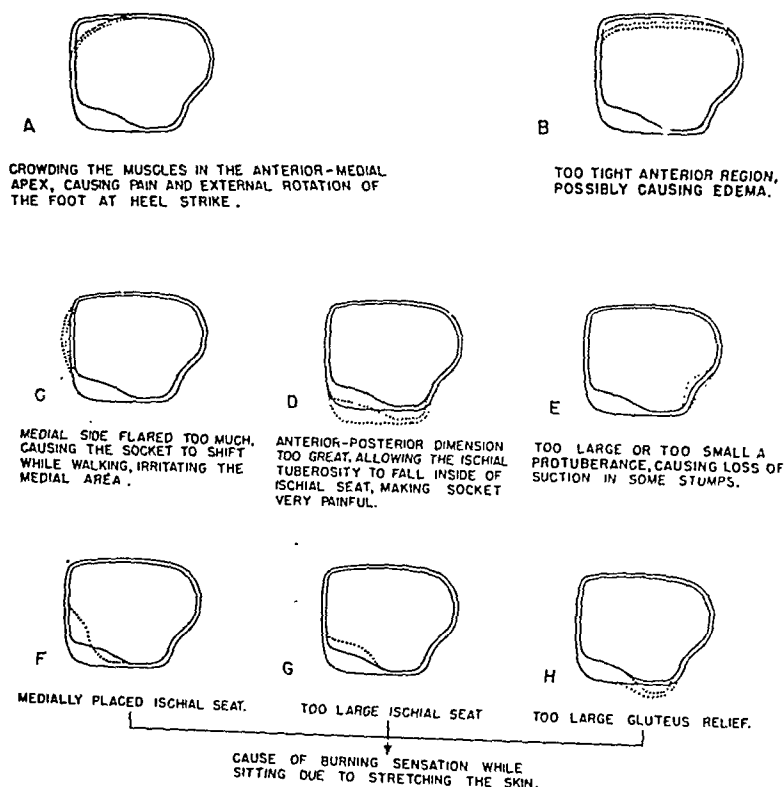


FIG. 8. Common errors in fit at top of socket.<sup>6</sup> Errors indicated by dotted lines.

conventional artificial limb. Those amputees harboring low grade osteomyelitis of the femur should be denied the fit of a suction socket. Patients with chronic dermatitis or fungus infection or eczematous rash on the stump should be excluded from wearing the suction socket until cured. The few patients with depressed scars at the top of the thigh should be denied this socket inasmuch as suction could not be maintained.

The importance of follow-up and constant vigilance of the suction socket wearer during his first four to six months cannot be over-emphasized. In fact it might be stated that too many surgeons discharge their patients after the fitting of any orthopedic appliance. To alleviate most complaints and to provide better professional service to the veteran orthopedic appliance wearer, the Veterans Administration is setting up Pilot Orthopedic Clinics throughout this continent in twenty-three of its larger regional offices. Five of these already estab-

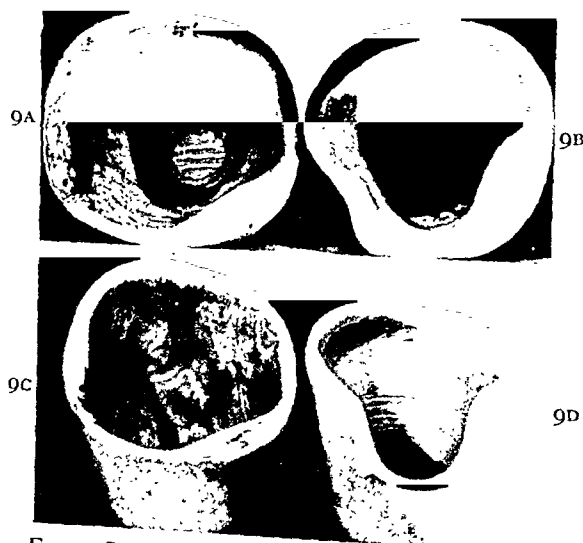


FIG. 9. Suction socket for the same stump; A and C, satisfactory; B and D, unsatisfactory.<sup>6</sup>

testing of new orthopedic devices these clinics have great potential value.

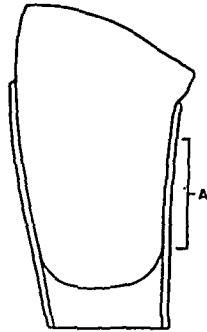


## SUMMARY

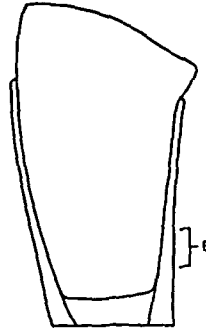
To recapitulate, the tentative conclusions on the current experimental use of the suction socket above-knee prosthesis are as follows:

1. The suction socket above-knee prosthesis

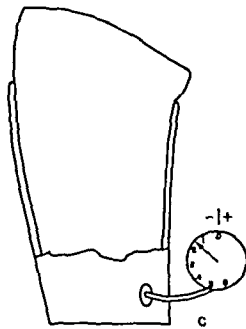
4. HEPP, OSCAR. Haft prothesen. *Ztschr. f. Orthop.*, 77: 219, 1944.
5. CANTY, THOMAS J. and WARE, ROBERT J. Suction socket for above knee prosthesis. *U. S. Navy M. Bull.*, 49: 216, 1949.
6. The Suction Socket Above-Knee Artificial Leg.



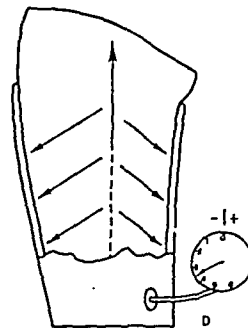
A.-TIGHT FIT IN THIS AREA WILL CAUSE EDEMA WHEN STUMP MUSCLES ARE CONTRACTED AS SHOWN IN D.



B.-CONE-SHAPED BOTTOM WILL CAUSE EDEMA BY CHOKING THE DISTAL END OF THE STUMP



C - NEGATIVE PRESSURE OF ONE AND ONE-HALF POUNDS PER SQUARE INCH WILL SUCCESSFULLY SUSPEND THE LEG EDEMA MAY OCCUR WITH AN INCORRECT FIT AS IN A OR B.



D.- A HIGH NEGATIVE PRESSURE INDICATES A VERY TIGHT FIT, PRODUCING FORCES TENDING TO PUSH THE LEG OFF. THE SOCKET MUST BE ENLARGED IMMEDIATELY.

FIG. 10. Errors in fit below brim of socket.<sup>6</sup>

is described and found to have been fitted to 211 veteran amputees.

2. Complete failures represent 4.3 per cent of the patients.

3. Inasmuch as 58 per cent of the patients have been wearing this prosthesis for four months or less, the favorable results cannot be construed as conclusive evidence for general approval of the suction socket prosthesis.

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## DISCUSSION OF PAPERS BY DRS. BENNETT AND THORNDIKE

DONALD GORDON (New York, N. Y.): Dr. Thorndike has given a brief but excellent comprehensive resume of the suction socket program in this country. I understand that in Germany it is extensively fitted and has been used since the recent war. After we have learned its advantages and shortcomings we should be able to do in this country what the Germans have accomplished so successfully abroad.

The Veterans Administration by developing and affording the fitting and use of this excellent type of prosthesis hopes to make it useful not only to battle casualties but also to civilian amputees. The

Administration hopes to demonstrate to the limb industry the undoubted value of this prosthesis in suitable cases.

I have been afforded an unusual opportunity as a V. A. consultant of observing and examining a group of twenty-eight suction socket wearers fitted in the Research Laboratory of the Prosthetic and Sensory Aids Service at the New York Regional Office of the Veterans Administration. They were a group of wearers fitted in the New York University Experimental Suction Socket Program. The wearers were selected from a group of sixty-eight as suitable to cooperate in further experimental work on shin, knee and ankle activating devices and to permit the two limb-fitters more time to apply and study the application of such devices to the suction socket as well as fitting experimental upper limb prosthesis. All the pilot wearers had been screened by psychologists and their stumps examined by surgical consultants who excluded unsuitable stumps for the various reasons mentioned by Dr. Thorndike.

They were fitted by, or their fitting in a suction socket school supervised by, the two skilled and experienced limb-fitters. Their stump muscles were tested for change in volume, strength and coordination by an excellent physical therapist who trained them in gait, alignment and posture. Their stumps were examined by me when the wearers came in for fitting or with complaints. This was done in the presence of the limb-fitter. I would discuss the medical problems presented and their relation to the fit of the socket. The fitter would in turn explain to me the possible reason for the fit causing the physiologic disturbance and how it could be corrected, made smaller with a liner or given more opening to prevent squeezes as changes in the stump occurred. This relationship is a most necessary one in fitting a suction socket and is to be carried out in planned Pilot Orthopedic Clinics. The limb-fitter would make such changes as were agreed upon and the stump and fit studied after the changes.

A common complaint was skin irritation in the abductor region or crotch which is relieved when a correct fit is obtained.

Skin folds or redundancy above the brim, due to the socket being too small just below the brim to permit the skin to be drawn into the socket, is relieved by opening the socket. A very small change either way or at different points in a well shaped socket accomplishes much for the correction of pressure points and comfort.

Discoloration is due to capillary congestion due to squeeze at the brim or deeper in the socket. Swelling or edema at the end of the stump is due to the same cause or overuse of the limb. I have seen swelling develop in a few hours or only after thirty-six holes of golf. One pilot had only a moderate degree of swelling. It may be obvious only

as an increased thickening of the pinched skin. If allowed to persist, it may develop into a bulbous stump with breaking down of the skin. This should not be interpreted as development of musculature as was reported in an outside case.

The treatment is removal of the socket for a period, correction of any squeeze in the socket and elevation of the stump above the heart with the patient lying on his back. Bandaging will aid only if it is done with uniform compression avoiding constriction above the end. I have seen only moderate swelling and discoloration which were quickly relieved by these measures.

Rubbing which irritates the skin may cause increased keratinization which by piling up causes small, hard pimples. If the skin glands become obstructed, cysts occasionally develop. Lack of careful hygiene of skin and disinfection of socket (I have advised  $\frac{1}{2}$  of 1 per cent aqueous solution of formalin wiped off with a damp cloth) are apt to produce superficial furuncles if contamination occurs. The stump sock of the conventional limb cannot be disinfected as easily as the suction socket. I have seen an amputee give up using a conventional socket and choose to use a suction type because of furunculosis. A careful exclusion of latent fungus infection should be done when skin irritation becomes persistent. I have seen a most discouraging case for the limb-fitter turned into one in which the patient was a satisfied suction socket wearer by the correction of a yeast fungus infection.

I have seen very few petechiae or small subcutaneous hemorrhages and these were found due to squeeze or pumping action in a loose socket, occasionally to a defective valve.

The usual discoloration develops as an elliptic area embracing the end and medial aspect of the stump which may fade to a lighter hue as time goes on or may endure as a pigmented area. I have seen no trouble from this nor had any complaints. There are few complaints of pain except that due to sore muscles from fatigue due to prolonged continuous overuse without rest. This is relieved by rest and warm bathing.

I have called attention to a few of the points spoken of by Dr. Thorndike to emphasize that a bad fit causes certain local physical conditions. These in turn increase the fitting problem which in turn adds to the other two. If the vicious cycle is not understood and corrected, mental antagonism develops and cooperation is lost.

To secure a satisfied suction socket wearer calls for tact and surgical judgment in cooperation with a skillful limb-fitter to reassure the amputee during the period of changes in the stump and development of his atrophied muscles until these are able to control the prosthesis. His reward will be the avoidance of an irritating abdominal belt

with hinge or shoulder harness and an inconspicuous limp in a comfortable, controllable limb.

It is quite apparent that by having beginners in its fitting see others using it successfully and talking with them makes them aware of its advantages and is most helpful in gaining their cooperation until a correct fit is obtained.

It has been a great privilege to be permitted to work in close contact with Dr. Thorndike's Service which affords promise of such an efficient aid in rehabilitating the above-knee amputee.

LOUIS G. HERRMANN (Cincinnati, O.): I realize that Dr. Bennett did not have the opportunity to discuss the problem of the care of the large mixed nerves of an extremity at the time of amputation. We are agreed that any injury to these large mixed nerves at the time of amputation may lead to severe phantom limb pains or chronic aching pain in an amputation stump.

It has been our opinion for a long time that centrally conducting axons carry abnormal impulses to the higher nerve centers and give rise to the syndrome which is called phantom limb pain. The time to do most for such pain is at the time of amputation and not six or eight months afterward.

Before this Association some years ago we reported our own experiences with the management of large mixed nerves at the time of amputation. We expressed the opinion that no injury to a mixed nerve should be permitted at the time of amputation whether that injury is by a small, hollow needle with novocain, alcohol or any other similar solution in it. We believe that the best way to reduce the incidence of phantom limb pain and pain in the amputation stump is to use a non-absorbable ligature and tie it tightly around the otherwise normal nerve above the site of amputation so that a band of scar tissue will develop at the point of pressure necrosis. The perineurium then seals over the end of the nerve without the formation of a neuroma.

Whether or not neuromas are actually responsible for phantom limb pain is disputable. I believe we can reduce the incidence of phantom limb pain by more careful attention to the large nerves at the time of amputation of the extremity.

With respect to Dr. Thorndike's paper, I should like to ask him one question. He did say extensive arterial disease was a contraindication to suction-type stumps? I think the suction socket is a real advance. We see a great number of patients who have extensive arterial disease or arteriolar disease and I would like to hear him say something about the indications for the suction stump in that type of patient.

JOSEPH E. J. KING (New York, N.Y.): I should like to ask a question of Dr. Bennett, Dr. Thorndike, Dr. Mayfield or anyone else present. Dr. Bennett spoke about the phantom limb pain but I should like to ask anyone in this audience if he

actually knows what to do for it. When the patient comes to you, what do you say to him? If a person needs resection of his stomach or an appendectomy, one can readily state, "Yes, we know what to do" but I have never known what to do for the phantom limb. A number of people with whom I have talked say that they usually try to get them to go to someone else.

ARTHUR R. METZ (Chicago, Ill.): Dr. Bennett has discussed a number of points to be considered in amputations as a group calling special attention to amputations through the foot.

It is good practice to maintain whenever possible a weight-bearing surface in doing a foot amputation. Whenever possible the flexor tendons should be preserved thus giving the patient a stump that he can control and walk on. In case too much of the foot is injured to preserve the flexor tendons of the ankle and there is still padding over the os calcis, Pirogoff's amputation should be performed which consists of ankylosing the os calcis to the end of the tibia and gives the patient a weight-bearing heel to which a satisfactory appliance can be fitted. Patients with this type of amputation get so they can carry on in a very active manner and do regular work.

In amputations below the knee it is desirable to have a stump 4 to 5 inches long as determined by measuring the tibia on x-ray films. In addition a more comfortably fitting stump can be made if the entire fibula is dissected out at the time of amputation and the perineal nerve severed high up so as to avoid pressure in the socket.

A stump of only 1 to 2 inches of tibia will be enough to give the patient knee action which is the important part in an amputation below the knee. An effort should always be made to preserve knee joint action in any amputation below the knee.

Dr. Bennett has pointed out many practical points to be observed in amputations in general.

R. J. BENNETT (closing): Dr. King mentioned the phantom limb. I have gone over the literature thoroughly and I have attempted to do some experimental work on this phantom limb. However, these are only subjective symptoms and it is impossible to do experimental work but we go by the signs and symptoms of people who have had phantom limbs.

You will find several cases of phantom limb in the literature. In one particular case one man had his arm taken off while in the air force during the last war; he returned and they had quite a time with him. He insisted on going back with his unit and he was not allowed to go. I believe the story goes that he had a particularly painful phantom limb. He was really disabled with it. Finally, a report came through to the effect that he was allowed to return to his unit and the phantom limb quieted down. He has not had any trouble since.

I think, undoubtedly, the psychiatric side plays

a part in phantom limb. By giving the procaine intravenously whereby we will get the local, regional and central wiping out of these impressions, we may be able to find out something. I do know that procaine has been used intravenously in the most painful cancerous conditions in which the patient has been absolutely unable to stand the pain and it has been wiped out by this intravenous injection.

AUGUSTUS THORNDIKE (closing): Relative to Dr. Kennedy's remarks from Dr. Gordon, I want to recall to your minds that the twenty-eight patients whom he examined were some of the very first that were fitted and they had every known complication, I think. The fit was too tight at that time but we have salvaged twenty-eight by follow-up and careful adjustment so that they are now considered satisfactory.

Remember, the patients in the series that I reported are all old amputees. They formerly had been on a temporary or permanent leg of the Army or Navy. They have had to be retrained entirely and many of them have had to come back innumerable times to be fitted and adjusted correctly.

Dr. Herrmann mentioned the phantom limb pain and also Dr. King. We have a research project under way now that shows some promise. I am not able to say very much about it but perhaps in another year we will have some results we can talk about. One of our research contractors is working on that problem now.

We are not prepared to say a great deal about the problem of arterial disease and contraindication

for suction socket at this time but we have fitted the suction socket to some definite arteriosclerotic individuals, veterans of World War 1. These veterans seem to be very happy and delighted that nothing has happened; they have worn it over a period of six months. We cannot say it is right in every respect. We do not know how far even these cases will go but it is promising.

I was interested to hear Dr. Bennett mention procaine intravenously. I am personally a little skeptical but I would like to see somebody report a series of cases. We are open-minded; we do want to lick this phantom limb problem.

I want to thank the discussors for what they have said and I hope that we may be able to report further on other developments in this research program on prosthesis.

LOUIS G. HERRMANN (Cincinnati, O.): I would like to bring up another question. I told you that we were interested in the prevention of phantom limb pain because we have tried almost every known procedure to relieve pain and have not been uniformly successful. Dr. Thorndike has also indicated that it is one of the big problems in the management of both severe trauma to an extremity as well as amputations following arterial disease, particularly arteriosclerosis. I should like to have a morning devoted to the problem of pain in an extremity sometime in the near future in this organization so that we can discuss all the failures (psychiatric and neurologic) and also the technical side of the problem of the relief or prevention of phantom limb pain.



# EARLY AMBULATION FOLLOWING INTERNAL FIXATION IN ARTHRODESIS OF THE SPINE

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*Minot, North Dakota*

IT is approximately forty years since the report of the first successful arthrodesis of the spine appeared in the literature. The operation was conceived as a means of permanently immobilizing a tuberculous spine and the attendant advantages of surgical arthrodesis soon were apparent. Time has proved the efficacy of the operation whose scope has been enlarged to include any condition that may be expected to benefit from immobilization. Few would contest its value in properly selected cases.

Improvement in surgical technic, increased knowledge of blood typing and compatibility, appreciation of the value of generous use of whole blood transfusions in combatting shock and introduction of intrathecal and intratracheal anesthesia and of anticoagulants and antibiotics have removed most of the hazards.

A major deterrent to a more general use of surgical arthrodesis, however, is the patient's unwillingness to submit to, or his economic inability to withstand, several months of postoperative immobilization in a plaster of paris cast in the recumbent position.

Appreciation by the medical profession of this state of affairs is attested by the appearance in the literature of various methods of internal fixation of the spine to promote early ambulation. King<sup>1</sup> described the use of screws to transfix the apophyseal joints and immobilize them after first performing a Hibbs type of arthrodesing operation. The postoperative period of immobilization is reduced by King to three weeks. A plaster cast is used in conjunction. This operation has been widely accepted and various authors have commented favorably upon the results they have obtained.

Although screw transfixion of the apophyseal joints has been stated to offer inadequate support, no concrete evidence to substantiate this criticism has been presented. King in his original report states that when the operation is performed upon a cadaver in the prone position and a hook placed under the fifth neural arch and upward traction made with a rope passing

over a ceiling pulley the body can be raised without the transfixion giving way. This would appear to refute the aforementioned criticism.

Previous evaluations of the success of the procedure have been concerned with evidence of fusion of the apophyseal joints. King<sup>2</sup> reports satisfactory fusion in 90 per cent of the forty-four cases he traced. This is based upon roentgenographic evidence of demonstrable movement of the apophyseal joints in oblique films of neutral, hyperextension and hyperflexion positions.

A review of the cases of arthrodesis of the spine in the New York Orthopaedic Hospital<sup>3</sup> during the ten-year period from 1938 to 1948 demonstrated an over-all pseudarthrosis of 16 per cent. With the usual Hibbs procedure with routine postoperative immobilization of several months, pseudarthrosis was 14 per cent at the lumbosacral joint whereas with the use of screw fixation it was 12 per cent. The comparison was less favorable at the fourth lumbar interspace. In this latter location the routine Hibbs fusion and immobilization resulted in a 23 per cent pseudarthrosis as compared with 52 per cent when screws were used.

Evidence of fusion of the spine based upon roentgenographic studies is of great practical and academic interest. Relief from symptoms and roentgenographic evidence of arthrodesis of the apophyseal joints are not closely correlated, however. King reported three patients unrelieved clinically with positive roentgenographic evidence of fusion and three patients in whom the opposite was true. Haggart<sup>4</sup> states that visualization of the apophyseal joint space roentgenographically is compatible with clinical arthrodesis as verified by findings at the operating table.

Relief from symptoms for which arthrodesis is performed is a practical evaluation of its success. Other data of equal practical importance are as follows: Can the patient return to his original occupation? Is he able to perform a full day's work? How much time has been lost? In this study a questionnaire was formu-

lated in such a way that the patient had to answer yes or no. The results of this questionnaire are seen in Tables I to IV. Although ninety-two patients have been operated upon, only fifty-two who responded to the question-

TABLE I  
BACKACHE

Pain	No. of Patients	Per cent
None.....	27	52
Slight.....	16	30
Moderate.....	9	18
Severe.....	None	None

TABLE II  
LEG ACHE

Pain	No. of Patients	Per cent
None.....	39	75
Occasional or mild.....	12	23
Severe.....	1	2

naire and whose postoperative period is one year or longer are included.

In each instance a Hibbs type of arthrodesis first was accomplished. Vitallium screws were then passed across the apophyseal joint. An attempt was made to transfix the facetial joints and enter the pedicle, a feat that can be accomplished more than half the time. Screw lengths up to  $1\frac{1}{2}$  inches thus may be used. In no instance has it been necessary to remove a screw because of nerve pressure and there have been no complications arising from the use of screws. Bone sufficient for grafting is obtained

from the exposed spinous processes and sacrum. Donor site pain occasionally experienced when bone is removed from the iliac crest and fracture of the leg occasionally experienced when the graft is removed from the tibia are eliminated.

TABLE III  
CONDITION OF BACK

Condition	No. of Patients	Per cent
Strong.....	24	46
Slightly weak.....	21	42
Moderately weak.....	7	12

The marked reduction in postoperative pain is striking and permits early ambulation. Originally the patients were kept in a recumbent position for three weeks as advocated by King. Among the first patients operated upon was a husky, former professional football player. Eight hours after the operation he got out of bed and walked around the hospital corridors. He left the hospital on the fourth postoperative day and drove his automobile 600 miles in the next three days. Twenty days later he began coaching a championship college football team. He has done all types of athletics and states he is entirely free from back and leg ache. As a result of this experience other patients have been urged to follow his example. To date nothing has occurred to discourage the program.

#### SUMMARY

The results obtained in fifty-two patients treated with Hibbs spinal fusion plus internal

TABLE IV

Diagnosis	No. of Cases	Day Ambulatory	Post-operative Day Discharged	Returned Same Job No. Per cent	Can Do Full Day's Work No. Per cent	Length of Disability (Mo.)
Compression fracture with or without disc....	5	7	16	3 60	3 60	2½
Subluxation of facets with or without disc....	9	6	12	8 90	8 90	4
Degenerative arthritis with or without disc....	14	12	15	13 90	13 90	2
Spondylolisthesis with or without disc.....	7	9	13	6 75	6 75	3
Normal spine x-ray with disc.....	13	8	13	13 100	13 100	2
Normal spine x-ray without disc.....	4	9	13	4 100	2 50	5
Workmen's compensation cases.....	14	7	11	11 71	12 85	3
Total group.....	52	9	12	90	86	3

fixation of the apophyseal joints with Vitallium screws are reported. There is a marked reduction in postoperative pain. On the average patients are ambulatory on the ninth postoperative day and leave the hospital on the twelfth. Recent experience indicates these figures may be materially reduced.

Of the patients 98 per cent have returned to their same occupation; 86 per cent are able to do a full day's work; 80 per cent are entirely relieved or at most have only a slight backache; 46 per cent state their backs feel strong and 75 per cent are entirely relieved of leg ache. None have a severe backache and one has continued to have a severe leg ache.

The poorest results are among the four who have a typical disc syndrome with normal roentgenograms of the spine and in whom no retropulsed nucleus pulposus was demonstrated at operation. Results are better among those patients who have been operated longest indicating that fusion may require many months. There have been no complications directly attributable to the use of screws and in no instance has it been necessary to remove them.

#### CONCLUSION

1. Internal fixation by greatly reducing postoperative pain and immobilizing the spine until bony ankylosis can occur permits early ambulation with all its attendant physiologic advantages.

2. In addition to the physiologic advantages of early ambulation there are the equally important economic advantages, namely, marked reduction of hospital expense and elimination of the psychic trauma associated with prolonged hospitalization upon reduced income, dwindling savings and long periods away from work.

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# COMMINUTED COLLES' FRACTURE\*

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IN spite of the vast knowledge that has accumulated concerning every aspect of Colles' fracture, it is surprising that the incidence of malunion with its attendant pain, loss of function and deformity remains high. The causes of malunion in this fracture are well understood yet a widespread concerted effort to prevent this complication has not apparently been made. An indifferent attitude has developed in regard to this deformity in spite of our knowledge that the best functional and cosmetic results are directly proportional to the excellence of the anatomic result.

It is the purpose of this paper to discuss one of the frequent causes of malunion in Colles' fracture, comminution, to review a method of treatment of this type of fracture and to present a series of patients with comminuted Colles' fractures treated by this method.

The frequency of comminution in this fracture is witnessed by A. W. White who reported an incidence of 74 per cent of comminution in sixty-six patients. The amount of comminution varies from gross shattering of the distal radial fragment with displacement of the multiple extra- and intra-articular fragments in various directions to the less extensive crushing limited to the dorsal and lateral cortices of the radial fragments at the site of fracture. In any case the fragments show a varying degree of instability following reduction and splinting by ordinary means. In moderate and severe cases this instability is perfectly obvious in the original x-ray films but it is in the numerous lesser comminuted fractures so common in elderly people that unstableness may be overlooked unless close attention is paid. In the latter group the dorsal crumpling of the fragments is often mistaken for impaction of intact cortices. However, the comminution and crushing, which in a sense amounts to loss of substance, will generally become evident in reduction roentgenograms after traction has been applied or soon thereafter when loss of reduction occurs due to the lack of intact bone dorsally and laterally.

## TREATMENT

No one denies that this fracture can generally be reduced easily by longitudinal traction combined with manual pressure and molding but there is disagreement as to the proper method of retention. It is agreed that comminuted fractures of long bones in other regions usually require special immobilizing precautions to maintain reduction. The reason that comminuted fractures of the distal radius should be exceptions to this belief is not entirely understandable. In severe cases of comminution the author is in accord with Bohler, Cotton, Darrach and others that reduction cannot be maintained by the application of a plaster cast alone; but it is further thought that particular means of immobilization should be used in many of the lesser degrees of comminution in order to prevent recurrence of deformity and malunion.

Bohler pointed out at least fifteen years ago that comminuted Colles' fracture could be maintained in reduction by using two transfixion wires and by applying axial traction and a plaster cast to include the wires. This procedure is simple, effective in preventing malunion and applicable to both young and old alike. It is my conviction that this method has not received the merit it deserves and has not been employed widely enough in the treatment of these patients.

The decision to use this method of splinting should be made immediately in cases of severe and moderate comminution. However, in cases in which there are milder degrees of comminution the decision may be more difficult to make because it may be possible to maintain reduction by a very efficient plaster cast. If a plaster cast or plaster splints alone are used and prove ineffective in preventing malposition, the double wire method can be adopted. Early and repeated postoperative roentgenographic films should disclose the loss of reduction so that the Kirschner wire method of retention may be used within the first seven to fourteen days

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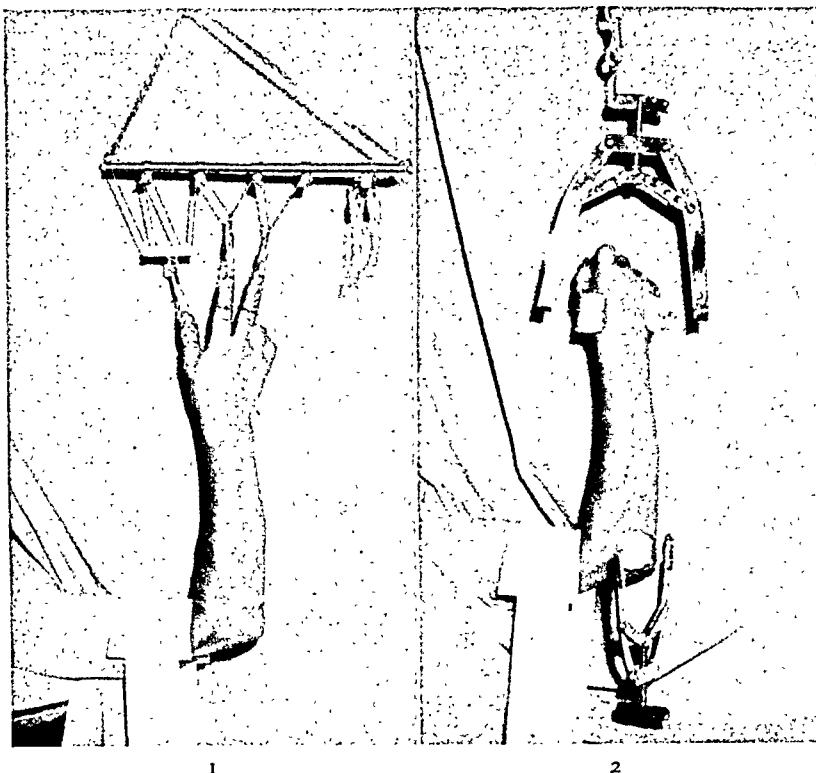


FIG. 1. The thumb, index and middle fingers are placed in finger traps and the upper extremity is suspended by the traction apparatus. The counter-traction loop is shown just above the elbow. The elbow, forearm, wrist and hand are prepared surgically and draped.

FIG. 2. The Kirschner wires have been inserted and the traction bows applied. The finger traps are removed and the distal bow is suspended. The major displacement is corrected by axial traction alone. Gentle manipulation completes the reduction.

after injury. Delay in making the decision to correct and splint properly a slowly increasing malposition at this stage of treatment is frequently the cause of later malunion.

*Technic.* Usually general anesthesia is employed and the thumb, index and middle fingers are placed in finger traps suspending the upper extremity with the wrist in neutral, the forearm in mid-position, the elbow in 90 degree flexion and the shoulder in 90 degree abduction. (Fig. 1.) Counter traction is applied by means of a loop of 4 inch bandage passed around the arm just above the elbow and extending to the floor where it is fixed by the operator's foot. The amount of traction can be varied as the case demands. It is to be emphasized that this longitudinal traction will correct most of the displacement and that very little further manipulation is necessary to bring about complete reduction. (Figs. 4B and 5B.) Forceful manipulation, including rocking of the fragments to free the impaction, is unnecessary and unwise

as it often causes more crushing and comminution, particularly in the more atrophic bone of the elderly patient. A Kirschner wire,  $\frac{1}{16}$  inch (.06 inch) in diameter, is inserted transversely through the bases of the second to fifth metacarpals and a second wire inserted transversely through the olecranon process about 1 inch distal from its tip. Traction bows are applied to the wires, the distal bow is suspended and the finger trap suspension removed. (Fig. 2.) The distal radial fragment is then gently manipulated so as to correct any residual dorsal tilt and displacement, radial deviation and supination twist. If there is residual displacement of major fragments, they can be molded together manually. The wrist is held in ulnar deviation and slight palmar flexion and the forearm in mid-position; portable x-ray films are then taken. When the reduction is excellent, a slightly padded, circular plaster cast incorporating the wires is applied from the axilla to the proximal flexion crease of the palm with the



FIG. 3. Forty-eight hours after reduction showing the long arm cast with the Kirschner wires bent down and secured by adhesive tape; complete shoulder, finger and thumb motions are done regularly.

elbow, forearm and wrist in the positions mentioned. With double wire fixation pronation has not been necessary to prevent recurrence of supination of the distal radial fragment. The thenar eminence is completely freed for full thumb motions.

*Postoperative Care.* The extremity is suspended by the distal traction bow for twenty-four to thirty-six hours to combat swelling. Roentgenograms are taken soon after reduction and are repeated at suitable intervals during the convalescence to be certain that reduction is being maintained. The bows are removed as soon as the cast is well solidified and the protruding wires are bent down and secured with adhesive tape for possible future use. (Fig. 3.)

Immediately after recovery from anesthesia full motions of the fingers are insisted upon for five to ten minutes of each waking hour. The shoulder is exercised through a full range of motion twelve times daily. The importance of these exercises can not be overemphasized and it is essential to be certain that they are being done properly and completely at each subsequent visit of the patient.

The wires are removed four to six weeks after reduction in young adults but never before six

weeks in the older patients. After removal of the wires a short or long arm cast is applied until union is firm both clinically and roentgenographically. Eight weeks of immobilization have been found necessary in these comminuted fractures because solid union occurs slowly, particularly in the zone of bone crushing. Discontinuing immobilization before this time adds a grave risk of redisplacement.

As soon as the elbow, forearm and wrist are freed, intensive hourly active motions are begun. It is to be stressed that the author has not found that the elderly patient develops persistent stiffness of the elbow or forearm as a result of such a cast nor is there any difficulty with the finger or shoulder motion if the patient will carry out the exercise program.

Motion and other forms of physical therapy applied to the wrist joint before the fracture is solidly united are mentioned only to be condemned as valueless and dangerous.

Outpatient visits after reduction are of great importance in attaining good results and these patients should be followed rather closely for at least six months. A prolonged disability has not been noticed in these patients. The usual patient shows prompt and progressive recovery



FIG. 4. A, T. C., male, age forty-four; severely comminuted Colles' fracture with considerable radial shortening, posterior and radial rotation and involvement of articular surface; B, showing the good reduction obtained by traction alone.



FIG. 4. C, T. C., thirty months postreduction; this is an excellent result from every aspect.

of function after the splinting has been discontinued.

**Review of Cases.** From March 15, 1946 to March 15, 1949, a three-year period, 123 patients with 124 Colles' fractures have been treated at the Guthrie Clinic and Robert Packer Hospital. The patients to be reviewed in this series consist of thirty-one patients with thirty-two comminuted Colles' fractures (25 per cent) who were considered sufficiently unstable to warrant treatment by the double Kirschner wire technic. Eight of these fractures (25 per

cent) were treated by manipulation and application of cast primarily but recurrence of deformity early in the convalescence plus the comminuted nature of the fracture prompted remanipulation and the use of wires to maintain reduction. This recurrence occurred in spite of

TABLE I  
AGE INCIDENCE OF COMMUNUTED COLLES' FRACTURE  
IN DECADES

Decade	Cases (No.)	Per cent
20-29	5	16
30-39	3	10
40-49	4	13
50-59	5	16
60-69	6	19
70-79	6	19
80-89	2	7
Total.....	31	100

using a cast from axilla to metacarpophalangeal joints with the wrist in moderate palmar flexion and ulnar deviation and the forearm in full pronation.

**Age and Sex.** The ages of the patients varied from twenty-one to eighty-three, 45 per cent being over and 55 per cent under sixty years of age. (Table 1.) Of the patients 64 per cent were females and 36 per cent males. It is of interest that seventeen (89 per cent) of the

nineteen patients over the age of fifty were females whereas nine (75 per cent) of the twelve patients under the age of fifty were males.

*Etiology.* As one would expect, the trauma causing the fracture was much more severe in those patients under fifty years of age while over this age the injury as a rule consisted of a fall upon the outstretched hand.

*Roentgenologic Studies.* The original x-ray films were studied thoroughly and the following features are noteworthy:

1. *Severity of Comminution and Displacement:* In this regard the fractures were classed as severe in fifteen, 47 per cent (Figs. 4A and 5A), moderate in fourteen, 44 per cent, and mild in three, 9 per cent. However, it is to be stressed that these thirty-two patients represent the most markedly comminuted and displaced fractures of the entire group of 124 Colles' fractures. Even the mild cases are potentially severe malunions.

2. *Involvement of the Radiocarpal Joint:* One or more fracture lines entering the radiocarpal joint with varying amounts of displacement of the articular fragments were present in nineteen patients (59 per cent). No involvement of the joint could be seen in thirteen instances (41 per cent).

3. *Degree of Posterior Rotation of Distal Radial Fragment:* The amount of posterior tilt is one index of displacement that can be measured in the roentgenograms but it does not necessarily indicate the seriousness of the malposition as the posterior rotation can be mild in an otherwise markedly comminuted and displaced fracture. The normal volar tilt of the distal radial articular surface is about 10 degrees. The amount of dorsal tilt in this series ranged from 15 to 60 degrees with an average of 36 degrees. One patient had a volar tilt of 7 degrees.

4. *Degree of Radial Rotation of the Distal Radial Fragment:* The amount of radial rotation is another displacement which is usually measurable but which does not necessarily indicate the seriousness of the displacement. The distal radial articular surface normally faces ulnarward or medially at an angle of about 25 degrees. Because of the severe displacement this angle could not be measured in four patients but in the remaining twenty-eight it ranged from 5 to 27 degrees and averaged 16 degrees.

5. *Fracture of Styloid Process of Ulna:* This

process was fractured in twenty-four patients (75 per cent) and was not fractured in six patients (19 per cent). A partial fracture of the head of the ulna including the styloid process was present in two patients (6 per cent).

6. *Shortening of Radius:* The amount of radial shortening was classed as severe in thirteen patients (41 per cent), moderate in eleven patients (34 per cent) and mild in eight patients (25 per cent). In the milder cases of comminution the shortening often effectively hides the posterior comminution which becomes evident only after full radial length has been restored by traction.

*Complications.* Complications in this series of patients have been uncommon and consisted of:

1. *Infection:* One patient had two short episodes of inflammatory reaction in the region of the fifth metacarpal at the site of a previous wire. In both instances the inflammation subsided rapidly under conservative therapy. No suppuration resulted and no sequestration could be seen in the roentgenograms.

2. *Sudeck's Atrophy:* One patient developed mild, post-traumatic, acute bone atrophy about one week after manipulative reduction and completely recovered in the next five weeks.

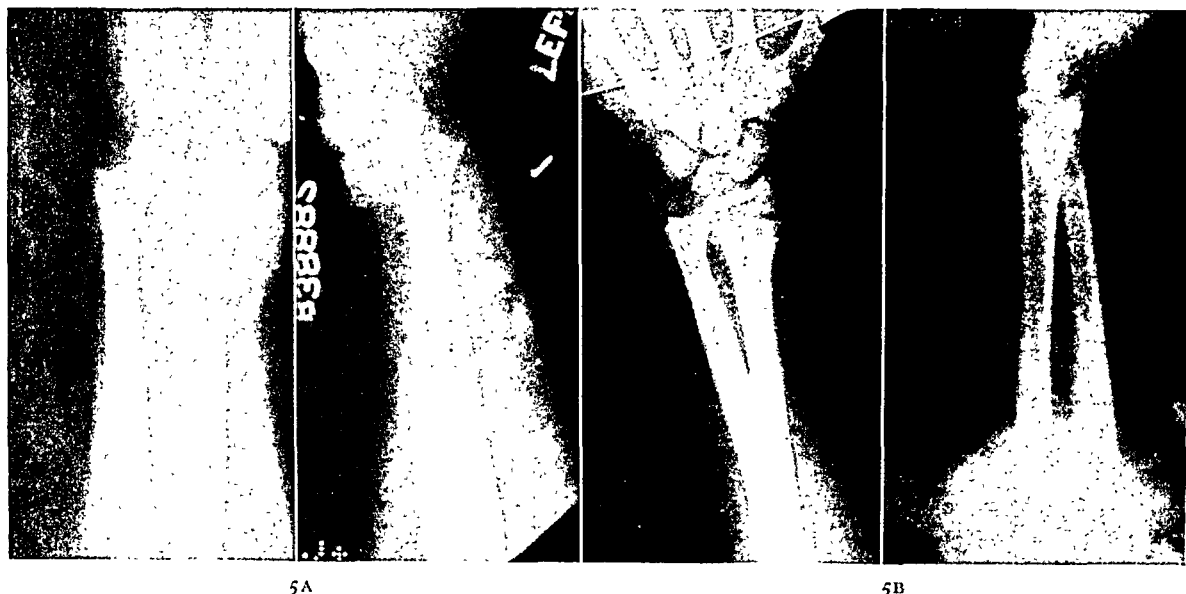
3. *Median Neuritis:* Symptoms of a mild median neuritis were noted soon after injury in one patient and complete recovery occurred in ten weeks.

4. *Periarthritis of the Shoulder:* Three elderly patients had mild periarthritis of the shoulder of the affected extremity. In two of these three patients the condition was asymptomatic and was discovered only by routine examination of this joint some time after reduction. At times it is difficult to impress the patient of advanced years with the importance of exercise to prevent this complication.

5. *Death:* One patient, fifty-seven years of age, suddenly died on the fifth postoperative day of a cerebrovascular accident or coronary occlusion. Autopsy was refused.

## RESULTS

In order to give an accurate result it was thought that at least six months must elapse from time of reduction to appraisal of the case. Twenty-four patients with twenty-five Colles' fractures have been followed up from six to thirty-six months after reduction. The remaining seven patients consist of six who have been



5A

5B

FIG. 5. A, W. C., male, age twenty-one; severely comminuted Colles' fracture with marked posterior and radial tilt, posterior displacement, radial shortening and displacement of articular fragments; note the finer crushing of the posterior cortex of the distal radial fragments (bilateral case); B, showing the excellent reduction by traction alone.

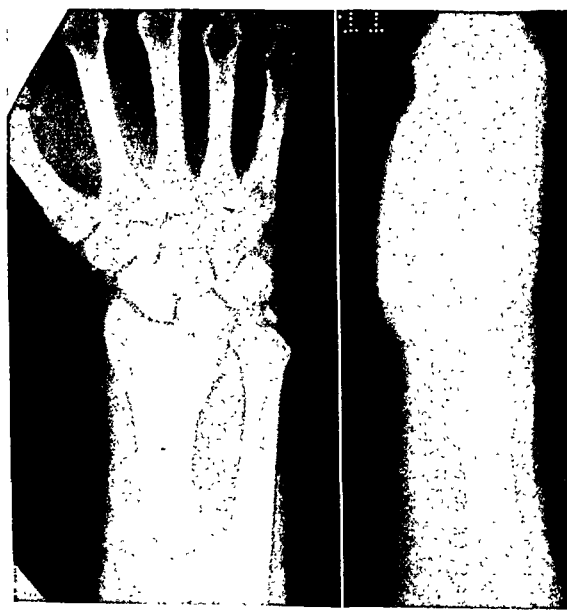


FIG. 5. C, W. C., sixteen months postreduction; the subjective and objective results are good but the roentgenographic result is only fair. Kirschner wires of small diameter bowed in the cast after reduction and allowed moderate recurrence of radial shortening.

followed up less than six months and one patient who died.

The subjective end results were secured by direct questioning in all cases. The patients with excellent results have no symptoms; they consider the upper extremity normal in every regard and are completely rehabilitated. The

patients with good results have only very slight symptoms and otherwise consider the extremity normal and are completely rehabilitated. Of these patients 81 per cent obtained an excellent or good result and there were no poor results from a symptomatic standpoint.

The objective end results were obtained from the final clinical examination of the extremity. The patients with excellent results have no or only slight variations from the normal as regards deformity, range of joint motion, muscle power, etc. The patients with good results have slight abnormalities in these regards. Seventy-six per cent of these patients had an excellent or good result and there were no poor results from an objective standpoint.

*Roentgenologic.* The final x-ray films were carefully reviewed and the results classified in the twenty-five wrists. No patient was considered absolutely normal from roentgenologic aspects. Every patient had solid bony union and there was no instance of moderate or severe malunion. Excellent results showed almost normal configuration of the wrist with no radial shortening at the radio-ulnar joint, smooth articular surfaces, no or very minor degrees of radial rotation and posterior rotation of the distal radial fragments; there was no other significant abnormality. (Fig. 4C.) Patients with good results had a slight change from the normal anatomy. Seventy-two per cent of the patients had excellent or good re-

sults and there were no poor results from a roentgenographic standpoint.

Twelve wrists (48 per cent) had some recurrence of posterior tilt of the distal radial fragments. This tilt ranged from 2 to 13 degrees and averaged 6 degrees. Ten wrists (40 per cent)

TABLE II

END RESULTS IN TWENTY-FOUR PATIENTS WITH TWENTY-FIVE COMMUNUTED COLLES' FRACTURES

Result	Cases (No.)	Per cent
Excellent.....	8	32
Good.....	11	44
Fair.....	6	24
Poor.....	0	0
Total.....	25	100

showed a volar tilt ranging from 2 to 12 degrees and averaging 5 degrees. In three patients the distal radial articular surface was in neutral, exhibiting neither a volar nor dorsal tilt.

In the twenty-five wrists the distal radial joint surface faced ulnarward at an angle varying from 15 to 27 degrees and averaged 22 degrees.

Recurrence of some degree of radial shortening was the most frequent cause for downgrading the roentgen result. (Fig. 5c.) In the twenty-five wrists thirteen (52 per cent) showed no radial shortening, three (12 per cent) had mild shortening and nine (36 per cent) revealed moderate recurrence of the radial shortening. It should be pointed out that five of these nine patients do not notice any wrist deformity and four notice a slight prominence of the ulnar head. On clinical examination in each instance the radial shortening was classified as mild, the radial styloid process being below the level of the ulnar styloid process but not to a normal degree. This deformity can be prevented as noted in the Comments.

*End Results.* By combining the subjective, objective and roentgenologic results in the twenty-five comminuted Colles' fractures, reasonably accurate end results can be determined. The average follow-up period is 14.3 months. Table II depicts the end results in these patients. Seventy-six per cent obtained excellent or good results and there were no poor results.

#### COMMENTS

The end results speak for the success of the Bohler method in treating comminuted Colles' November, 1949

fractures. No moderate or severe malunion occurred in this series of patients in spite of their representing the most severely comminuted and displaced fractures of the entire group of 124 Colles' fractures. The absence of malunion may account for the lack of development of any case of traumatic arthritis which, however, may be a later complication in some of these patients. In this regard it is of interest that there was no significant difference in the end results in those patients with fracture lines entering the radiocarpal joint as compared to those without involvement of this joint.

The recurrence of a part of the original radial shortening in 48 per cent of the patients can be explained on an error in application of Bohler's technic. In each case the resultant deformity was mild as judged both by the patient and by clinical examination. However, these patients had inferior end results when compared to those without shortening. In every case in which the roentgenogram indicated a moderate recurrence of radial shortening a Kirschner wire of small diameter had been used and the wire had not been prevented from subsequent bowing in the cast by applying screw caps or lock nuts to the ends of the wires after the plaster had set. Radial length was then lost in the postreduction period due to the instability of the fracture and the lack of tautness of the wire (Fig. 5c.) This complication can be prevented by using Kirschner wires of  $\frac{1}{16}$  inch diameter as described under Technic or by using the lock nuts on wires of smaller diameter. In eleven cases in this series in which the larger wire was utilized no significant radial shortening occurred. (Fig. 4c.)

Although every effort should be made to reestablish the normal volar tilt of the distal articular surface, a few degrees (up to 10) of posterior rotation did not affect the result adversely. The results were not influenced by the presence or absence of bony union of the ulnar styloid process.

It is still frequently expressed in this era of enlightened geriatrics that the older patients with Colles' fractures obtain the best results if the fracture is more or less neglected and early physical therapy instituted. This attitude is not shared by the author as it is thought that the old patients deserve the same chance for as good a functional and cosmetic result as the younger patients. There was no patient of advanced years in this series in whom it was re-

gretted that malunion was prevented because the final result is judged better than the result that could possibly have been obtained if the fracture had not received optimum treatment.

#### SUMMARY AND CONCLUSIONS

1. Comminution of varying degree in Colles' fractures is much more common than generally recognized and is a very frequent cause of malunion. However, malunion in such cases is not inevitable and can be prevented.

2. Although reduction of this type of fracture is not difficult, malposition often promptly returns when the usual methods of immobilization are used.

3. The reduction of comminuted Colles' fractures can be maintained by Bohler's method of incorporating two transfixion wires in a plaster cast. It is recommended that this form of treatment be used more widely not only in the fracture with severe comminution but also in many of the unstable fractures with mild comminution.

4. To prevent redisplacement at least eight weeks of immobilization are necessary because solid union of the multiple fragments occurs slowly.

5. The value of repeated, complete active motions of the fingers and shoulder from the start of treatment and of the immobilized joints as early as possible can not be overemphasized.

6. Thirty-one patients with thirty-two comminuted Colles' fractures treated by the Bohler technic have been reviewed. Good or excellent results were obtained in 76 per cent of the patients followed up for a sufficient time; there were no poor results and no malunions.

7. The optimum treatment of Colles' fracture should not be withheld from any patient because of age alone. Elderly patients in this series responded well to the treatment described.

8. It is thought that the problem of malunion of the Colles' fracture can be solved if sufficient interest in this fracture can be aroused.

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# ARTHRODESIS OF THE WRIST JOINT

## GRAFT FROM INNER TABLE OF THE ILIUM

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**A** RTHRODESIS is a very valuable procedure in a variety of disorders of the wrist. A limb with no other disability than this gives surprisingly good function and this can be promised when the pre-existing condition does not interfere with finger movements or rotation of the forearm.

This is a report of an unselected series of forty-nine consecutive arthrodeses of the wrist. Twenty-seven of these were personal cases and twenty-two were done by seven colleagues, using essentially the same method. The method, as illustrated in Figure 1, was evolved during the war years with the R. A. F. Orthopaedic Service and, since then, at the Queen Mary Veterans Hospital and the Royal Victoria Hospital in Montreal covering a period of eight years. During that time a large number of traumatic conditions of the wrist joint have been seen and a small number of a variety of other conditions.

Most methods for arthrodesis of the wrist described in the literature have been given a previous trial. Any adequate excision of hyaline cartilage with immobilization completely enough and long enough, with or without the use of a graft, will produce a stiff wrist. The most satisfactory arthrodeses, however, appear to be those which have the most extensive fusion, namely, radiocarpal, mid-carpal and carpal metacarpal joints.

It is sometimes claimed that partial fusions are best. In our experience they are often painful and interfere with function of the limb. We cannot see the use of a few degrees of carpal metacarpal movement which may be painful and is rarely under muscle control. The callus of a partial arthrodesis cannot consistently be restricted to a particular joint compartment but it is essential to preserve the first carpometacarpal joint and preferable to preserve the fifth when there is no arthritic involvement. Our method should, therefore, give as complete a fusion in the shortest period of time as is consistent with function if it is to be the optimum procedure. This method in practice, as shown

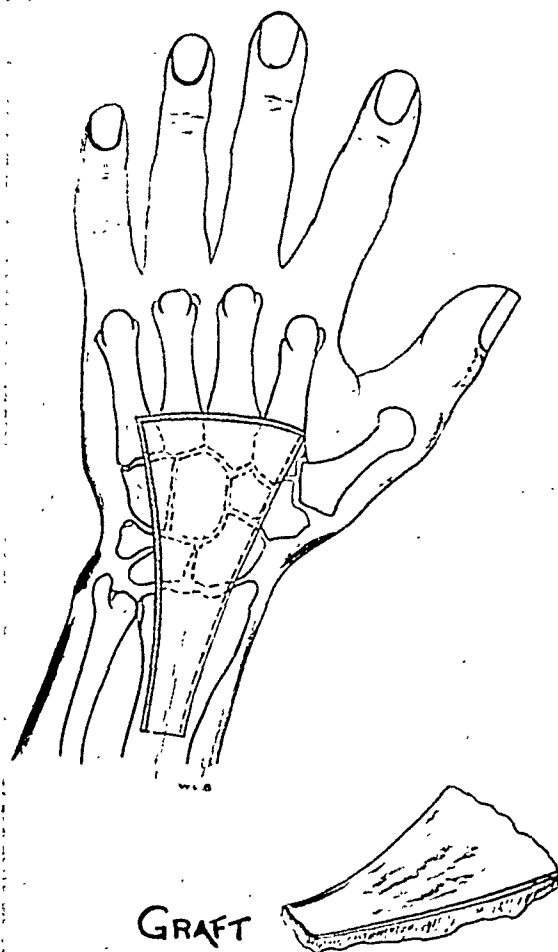


FIG. 1. Arthrodesis of wrist; indications are old ununited fracture scaphoid with advanced arthritis, osteo-arthritis including degenerative arthritis due to trauma, infective arthritis, tuberculous arthritis, rheumatoid arthritis; paralysis, infantile-spastic-traumatic, and congenital deformities. Technic used is as follows: use pneumatic tourniquet; cut deep bed in carpus, lower end of radius and second to fifth metacarpals; graft from inner table ilium cut in a fan-shape to fit; and immobilize until x-ray evidence union which is usually four months; graft from inner table of ilium with natural curve and cortical surface for dorsal aspect and cancellous surface for graft bed. by the follow-up, often does achieve this aim. It is our clinical impression that it is more often successful than the other methods commonly used. The procedure has been used long enough to enable us to report both the advantages and



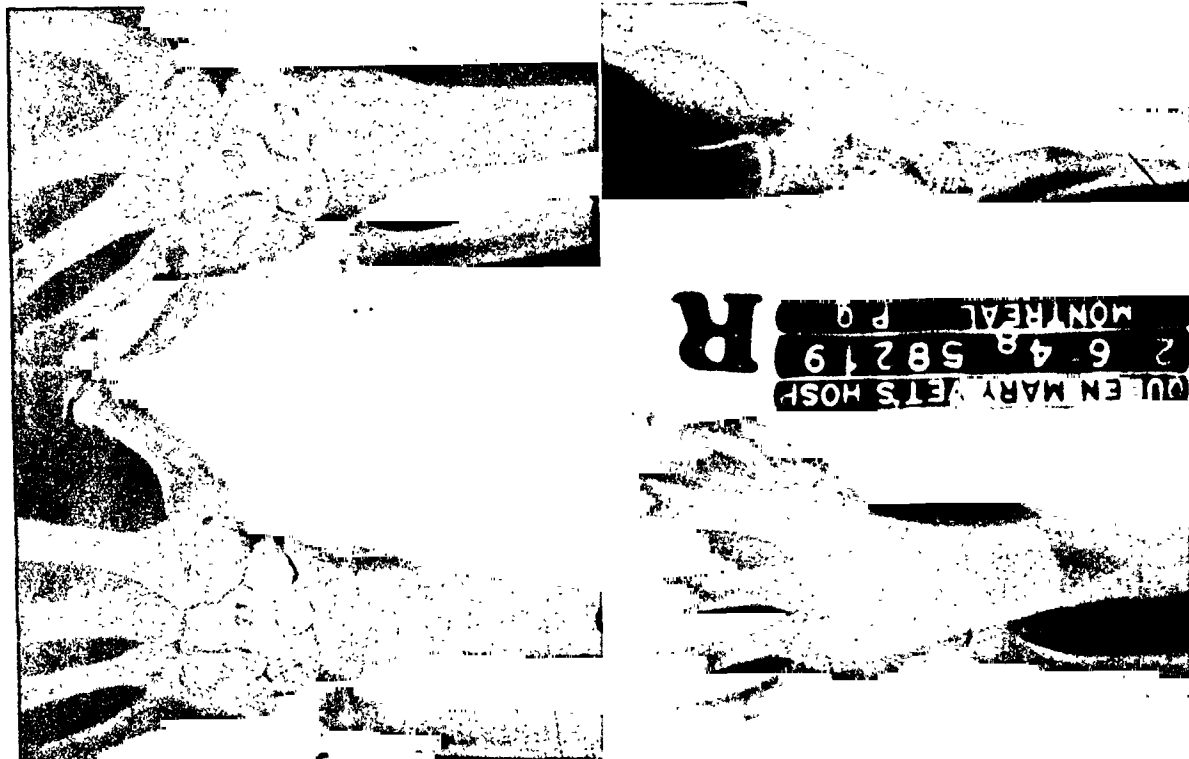


FIG. 2. Fracture of carpal scaphoid with established non-union and secondary osteo-arthritis. Note multiple cysts which are also present in the other wrist. Possibly this is Jungling's disease with a pathologic fracture.

the disadvantages and how complications are to be avoided.

In our experience the most common single cause (twenty-one cases) of a stiff and painful wrist of the severity requiring fusion of the joint, has been old ununited fractures of the carpal scaphoid with secondary osteoarthritic changes. The usual story is history of injury to the wrist (with or without x-ray studies) diagnosed as a sprain and untreated. Symptoms persist until eventually it is recognized that there is an old fracture of the carpal scaphoid, with established non-union and fully developed osteoarthritis, with continuing degeneration in the function of the wrist. (Fig. 2.) Approximately 90 per cent of these are relieved by various procedures and are able to tolerate their disability. The others which do not get alleviation of symptoms are fused. They have passed the stage in which curing the non-union of the scaphoid by bone grafting has any effect on the pain and stiffness of the wrist joint.

Arthroplasty of the wrist joint in these cases by excising the proximal row of the carpus rarely gives a satisfactory result. There is usually painful limitation of movement, a good

deal of weakness and progressive degeneration due to traumatic arthritis. (Fig. 3.)

It appears that osteo-arthritis affecting one portion of the wrist joint, for instance, the radiocarpal compartment, will spread until it involves the mid-carpal and carpal metacarpals; for this reason arthrodesis is necessary. The best function of the limb is achieved when the wrist is a solid block of bone; pain is abolished and the limb used. Until we learn to do a sensory denervation without producing neurotrophic changes, arthrodesis will be the best procedure for severely damaged wrists.

In any fracture involving the carpal bones, including the lower end of the radius and the bases of the metacarpals, if there is not a hair-line reduction and a minimum of joint involvement due to callus, traumatic arthritis may arise which in the more severe cases requires arthrodesis. Accurate reduction and relatively early active movement should keep these to a minimum. Malunions due to improper fracture treatment are still too commonly seen (Fig. 3.)

In infective arthritis we may find that the infection thoroughly ankyloses the joint; and if it has been splinted in good position, a satis-



FIG. 3. A comminuted fracture dislocation of the wrist joint treated inadequately resulted in a stiff and painful wrist; arthroplasty done elsewhere did not improve matters. Good function was restored to the limb by excision of the lower end of the ulna and fusion of the wrist.

factory end result is obtained. Very commonly, however, the ankylosis is incomplete; residual movement is painful and because of this there is marked disuse atrophy and gross interference with the function of the limb. Furthermore, the small range of movement present predisposes to flares of the old infection. More often than not, these cases of painful partial ankylosis are in a position of deformity. For all of these, excluding other contraindications and under antibiotic control, arthrodesis gives a very satisfactory answer.

In tuberculous arthritis there are many factors to consider. It is a local manifestation of a systematic disease and it is most important that all available local and general measures are taken to build up resistance to the disease. When the patient shows good resistance, as indicated by gain in weight, general well-being, normal sedimentation rate and a normal hemogram, arthrodesis should be considered. If a discharging sinus were present, it should first be cleared up by both local and systemic use of streptomycin or aureomycin. Provided there is a healing reaction as indicated by some recalcification in the region of the disease, it is not necessary to delay the operation further. (Fig. 4.) Liebolt reports that of twenty-five tuberculous wrists treated conservatively, none were cured; of twenty treated by his method of fusion, 60 per cent were cured. We have only

three cases of tuberculous wrist to report but they all show satisfactory arthrodesis and cure.

Rheumatoid arthritis usually shows a deformity which requires a wedge resection as part of the procedure in order to obtain the optimum position.

The chief value of the procedure in spastic paralysis is to improve the appearance of the hand and the function of the limb in that the fused joint is easier to handle than a curled-up spastic one.

In infantile paralysis it is often an invaluable procedure as part of the reconstructive program giving stability and allowing better function of tendon transferences.

The operation is carried out using a pneumatic tourniquet and Lane's "no touch" technic. The incision 4 inches in length is centered over Lister's tubercle. The extensor retinaculum is carefully dissected back so that its subsequent repair is easy. The common extensors are retracted to the ulnar side, extensor pollicis longus is released from Lister's tubercle and subperiosteal and subcapsular sharp dissection is done, exposing the lower  $1\frac{1}{2}$  inches of the radius, all the carpal bones and the bases of the second to fourth or fifth metacarpals. In doing this the extensor carpi radialis is, of course, peeled off with its capsular and bony attachment. A fan-shaped bed is then outlined with a motor saw and completed with

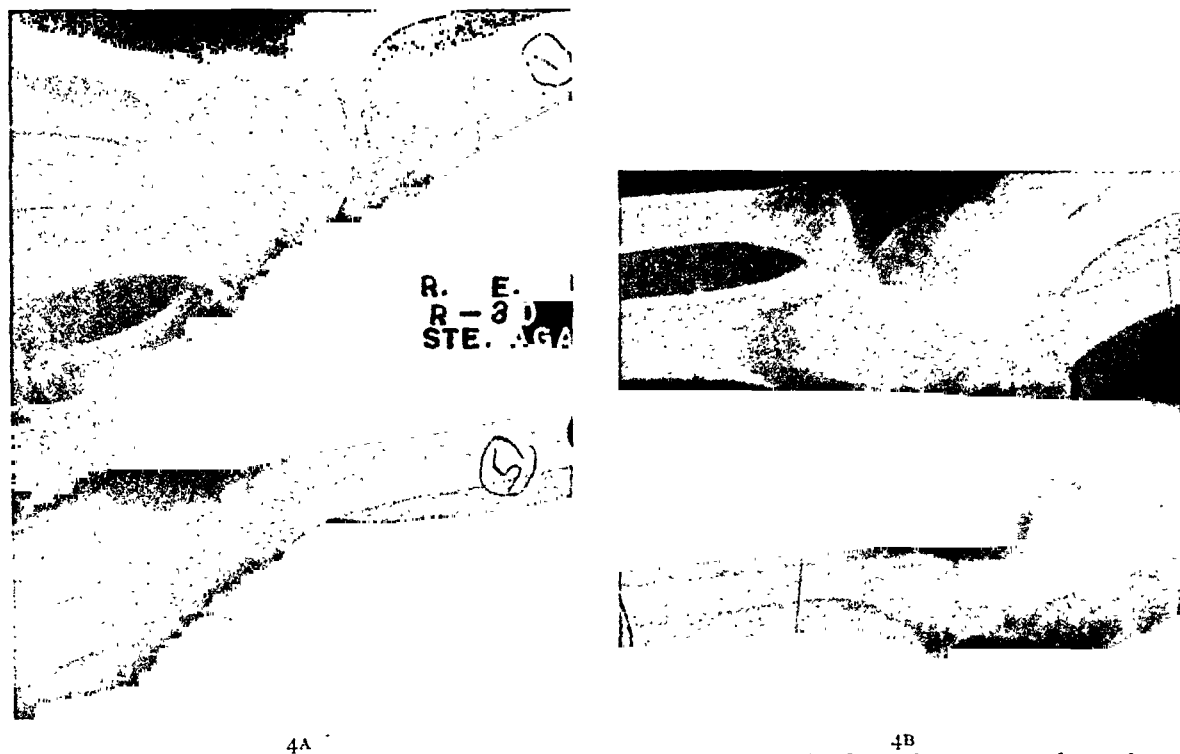


FIG. 4. A and B, tuberculosis of the wrist joint, immobilized postoperatively in plaster fourteen months; patient was under sanatorium treatment for this and pulmonary disease. Arthrodesis is sound and the lesion has remained healed.

the cutting burr, then deepened with curved osteotomes. The proximal and distal margins are undercut deeply and the entire bed is deepened a full  $\frac{1}{2}$  inch or more. A pattern of this bed is then made using silene cloth and from this an iliac graft is cut to fit. The graft is then pressed into position with traction on the wrist. Dorsiflexion into the optimum position is done, firmly impacting the graft. The capsule and periosteum are easily closed if the graft has been deeply enough inlaid; this is necessary to leave a smooth gliding surface for the tendons. It is not essential to reconstruct Lister's tubercle but the extensor retinaculum must be carefully repaired.

The iliac graft is taken by using a 4-inch incision extending along the crest of the ilium from the anterosuperior spine. A subperiosteal exposure of its inner surface is then done. With the use of deep abdominal retractors, the inclination of the inner surface of the ilium can be seen. Using numerous thin osteotomes, a graft is taken as thick as possible in order to leave an intact outer cortical surface. The deep portion of the graft is best separated with curved osteotomes. An alternative donor site occasionally used has been the curved outer

surface of the ilium just anterior to the postero-superior spine. These two regions give a curved graft with a concave cortical surface and a convex cancellous surface which fulfills the requirements. This type of graft unites more readily than a tibial graft and more certainly than either iliac chips or an osteoperiosteal graft.

The optimum position for arthrodesis varies between 20 and 25 degrees of dorsiflexion, with the third metacarpal and radial shaft in the neutral position. Position during fitting of the graft and also molding of the plaster is an important thing. There are four points to watch out for in positioning the hand, all of which are covered if one considers the position of the closed fist resting on the flat surface: (1) the degree of dorsiflexion; (2) the third metacarpal and radial alignment; (3) rotation of the hand to the radius and (4) the formation of a metacarpal arch.

The inferior radio-ulnar joint is usually a separate joint compartment from the carpal joints and this is, of course, not encroached upon. If, however, there is damage to this joint as an associated injury, it is best dealt with by excision of the lower end of the ulna. (Fig. 3.)

This produces a satisfactory result, if the pronator quadratus is not damaged, and full power will be preserved. If there has been a gross forearm injury with damage to the interosseous membrane and the superior radio-ulnar joint, excision of the lower end of the ulna is inadvisable, as instability and symptoms due to this will persist. In such a case possibly arthroplasty of the inferior radio-ulnar joint should be carried out as a separate, later procedure. Excision of the lower end of the ulna is only an innocuous procedure if these conditions are met.

If arthrodesis is indicated in young people, the radial epiphysis must be preserved; if it is already damaged by injury or disease, it must be completely fused in order to prevent subsequent deformity.

The first carpometacarpal joint is always preserved; if it were involved in the original disease or injury, we would prefer to do an arthroplasty at a later stage if possible.

When there is both damage to the inferior radio-ulnar joint and the necessity of doing a tendon transference, the ulnar approach has been used as described by Smith-Petersen (a deep slot is cut through the carpus curved to take this iliac graft). This has the advantage of keeping dorsal scarring, which might interfere with the tendon transference, to a minimum.

The routine postoperative procedure is to apply a full arm plaster cast extending from the distal palmar crease and the proximal I.P. joint of the thumb. This is split in its entire length to allow for the postoperative reaction. If we neglect the arch in our foot casts we produce flat, painful feet. It is not so well recognized that the same error in hand casts produces an appreciable loss of the power to grasp. The limb is elevated and if reaction is at all marked, circulation is improved by doing a sympathetic block. About the twenty-first day the cast and stitches are removed. This should be done carefully in order not to strain the graft or lose the position of dorsiflexion. A light forearm cast is then applied and molded well into the concavity of the radius in order to control rotation. This is then reinforced by aircel and should be retained for about three months. Aircel by itself does not mold well and it would be necessary to carry the cast around the elbow to control rotation if this were used alone. It is a very valuable reinforcing material, however,

and eliminates the danger of non-unions due to cast breaks or refracture of the graft.

At about three to four months we reach a stage called "firm union" when it is safe to remove the cast and use the hand lightly. There is an intermediate stage at about four to five months called "sound union" when light work is permissible (lifting up to about 10 pounds). There is a final stage at about nine months called "consolidation of union" when heavy work can be done. These stages are determined by characteristic x-ray findings and not the lapse of time.

In dealing with a tuberculous wrist or an uncooperative patient with any condition we should continue our external fixation until we have "consolidation of union." It is not necessary in the others but it is better to err on the side of excessive protection.

Forty-nine arthrodeses have been done up to April, 1949, for the following conditions: fractures of carpal scaphoid with osteo-arthritis, twenty-one; compound fracture dislocation of wrist, nine; nerve lesions with wrist drop, six; fracture dislocations of wrist, two; Keinbock's disease with secondary osteo-arthritis, three; tuberculous arthritis, three; fracture of semilunar, one; infective arthritis, one; osteochondritis dissecans with osteo-arthritis, one; rheumatoid arthritis with deformity, one; and Jüngling's disease, one.

The time for union (first operation) was as follows: united in three months, twenty-eight; four months, nine; five months, two (prolonged by poor fit of the graft); six months, one (tuberculous); twelve months, one (tuberculous); fourteen months, one (tuberculous); and sixteen months, one (prepenicillin days with a flare of old infection).

The time for union (second operation, four cases) was as follows: united in three months, one; incomplete, three. Two may be attributed to broken casts; two were due to starting heavy work too soon.

In regard to non-unions (two cases) one may be attributed to operative technical error; one was due to an infection with abscess at two and one-half months postoperatively. These did not have a second operation as the close fibrous union gave a good enough function for the patients to carry on with their work.

The end results (anatomic, functional and symptomatic) were as follows: excellent twenty-

five, good fourteen, fair four and incomplete six.

## COMMENT

Analysis shows no one surgeon had more than two significant complications regardless of the number of arthrodeses done. The complications reported are all avoidable. The incidence is lower than most reported series but is not as good as one. Good results depend on careful operative technic, postoperative care and follow-up, and these results improve with experience.

*Acknowledgments.* We wish to express our appreciation to Sir Reginald Watson-Jones, Air Commodore H. Osmond Clarke, S/L E. W. Somerville and Drs. J. G. Shannon, A. L. Walker, W. G. Breckenridge, C. E. Lamoureux, J. M. McIntyre, Gavin Miller and J. G. Petrie.

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# ADULT INJURIES OF THE RADIAL HEAD AND NECK\*

## IMPORTANCE OF TIME ELEMENT IN TREATMENT

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THIS report comprises a review of all adult radial head and neck injuries treated on the Fracture Service of the Presbyterian Hospital from 1938 to 1947. A total of 261 such injuries have been studied of which 113 are sufficiently documented to

fresh bleeding and recurrence of intracapsular tension. Active motion within pain limits is begun the next day. The use of a sling or splint for two weeks or longer as advocated by some authors has prolonged disability out of all proportion to the severity of the injury.

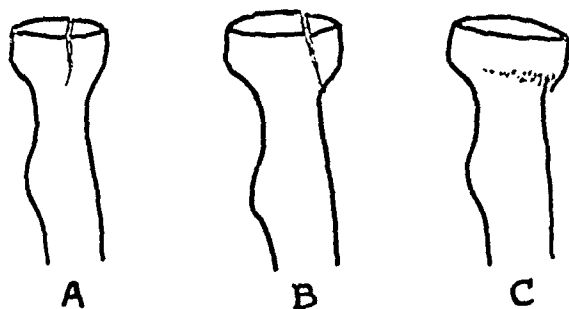


FIG. 1. A, linear fracture through articular surface of radial head; B, chisel-type fracture; C, fracture through neck with slight tilt of head.

form the basis of this report. These fractures are classified in three groups according to their pathologic condition. Epiphyseal injuries are omitted and will be reported separately.

### GROUP I

Group I, consisting of seventy-nine patients, includes undisplaced fractures of the radial head. Most of them show x-ray evidence of a linear vertical fracture through some part of the articular surface of the radial head. (Fig. 1A.) In some there is a chisel-type fracture extending from the articular plateau through the cortex of the neck (Fig. 1B) and in others the cortex of the radial neck is buckled with a slight tilt of the head. (Fig. 1C.)

These fractures *per se* require no treatment. The joint capsule becomes distended with blood which causes gradually intensified pain and limitation of motion. Treatment is directed toward tense hemarthrosis. Aspiration of the elbow joint removes encapsulated blood, relieves pain and improves motion at once. A sling or splint for twenty-four hours discourages

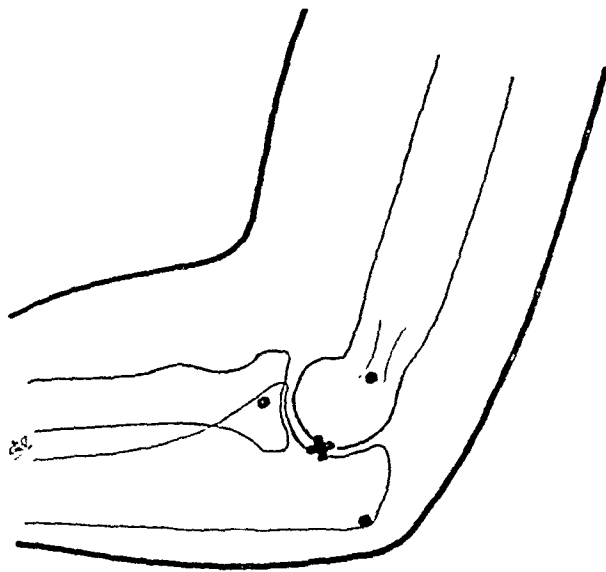


FIG. 2. Landmarks for aspiration of elbow joint.

Aspiration is performed from the lateral side of the elbow using a point of entry centered between three bony landmarks, the lateral epicondyle, the radial head and the tip of the olecranon process. (Fig. 2.) This must be performed with strict sterile technic. The skin is shaved and cleansed and the operator's hands scrubbed and gloved as for major operations.

Patients treated by this method enjoyed the greatest symptomatic relief and the earliest return of function. Fifty-nine per cent of undisplaced fractures were treated by aspiration. Seventy-six per cent of these gained full motion in thirty days. Of the remaining non-aspirated patients only 44 per cent gained full motion in an equal length of time. Those

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patients with limited motion at the time of clinic discharge gained full motion in three to six months regardless of type of treatment. The average length of follow-up was one year and eight months. Final rating was 4-4-4 for 75 per cent and 4-3-4 for 25 per cent

#### SUMMARY OF GROUP I

TOTAL CASES TREATED 212 OR 81 PER CENT OF ALL INJURIES OF WHICH SEVENTY-NINE ARE ADEQUATE TO REPORT

Group 1.....	Aspirated	Non-aspirated
Total 79 cases.....	47 cases	32 cases
Full motion in 30 days....	76%	44%
Average clinic Rx all cases	30 days	
Average follow-up all cases	1 yr. 8 mo.	
Final rating all cases.....	4-4-4 for 75%; 4-3-4 for 25%*	

\* 4-3-4—(3) Occasional slight pain with use and bad weather ache.

Final rating denotes A—S—E. A represents anatomy, S, joint motion and symptoms and E, economic rehabilitation; 4 equals 100 per cent; 3 equals 99 per cent to 76 per cent, etc.

of all patients in this group. The 25 per cent were marked down only for slight occasional pain with use and occasional bad weather ache. Anatomy and function were perfect in every patient. Results of Group 1 cases are summarized in Table 1.

#### GROUP II

Group II, consisting of twenty-three patients, includes displaced fractures of the radial head with an intact joint capsule as demonstrated by clinical signs of hemarthrosis. All fractures in this group were treated by complete excision of the radial head through a lateral operative approach. Recognition is given to those few fractures in which fragments may pierce the joint capsule laterally or posteriorly. None was encountered in this series but they belong to this group and should be treated similarly. Fractures in this group include complete avulsion and rotation of the radial head, fracture of a sector of the head with depression and separation, fracture of the neck with tilt of the head or gross comminution. The mechanism of fracture is a fall on the outstretched hand with impingement of the radial head against the capitulum. The cartilage of the capitulum was lacerated or fibrillated in 30 per cent, but fracture of the capitulum was not encountered.

Whether or not to remove the head is a matter of judgment. Experience has proved beyond question that far better results are achieved if all displaced fractures of the radial head are treated by excision of the entire head followed by early active motion, rather than by attempted closed reductions that seldom succeed and prolong immobilization. If degree of displacement does not justify active motion within twenty-four hours, the radial head should be removed.

Operation is performed through a lateral incision over the radial head just posterior to the common extensor tendon which provides a practically bloodless field. The dorsal interosseous nerve two fingerbreadths below the radial head is respected both by incision and retraction. Removal of fragments alone or partial removal of the head has been abandoned as entirely unsatisfactory. Clean excision of the entire head through the neck with an osteotome proximal to the orbicular ligament and cauterization of the raw surface of the radial neck with the electrocautery, is the operation of choice. All patients in this group were so treated.

The decision to operate should be made at once and the operation performed immediately within the first twenty-four hours after injury. Active motion within pain limits is started the next day and the patient is instructed that the optimum period of recovery of function is during the first few weeks following operation and he is encouraged to gain all possible motion within this interval.

The argument has been advanced that excision of the head may result in shortening of the radius with disability at the lower radio-ulnar joint. This argument is tenable only in children. Neither by x-ray nor clinical measurement were there any instances of change in length of the radius or complaints of malfunction at the wrist in adults. The only observed departure from normal anatomy besides the absent radial head was a 5 degree lateral instability of the elbow in four patients.

The best results were achieved in those patients operated upon within twenty-four hours following injury. They required the shortest period of postoperative treatment and gained the earliest return of function. Those operated at four to seven days and one to six months required longer active treatment and were slower to regain function.

## GROUP III

Group III, consisting of twelve patients, includes displaced fractures of the radial head associated with dislocations of both bones of the forearm at the elbow. This group of injuries differs from Group II in one essential detail.

draw attention to this group of radial head fractures distinct from other displaced fractures of the radial head"? It is because this type of fracture, with its anterior extracapsular pathologic condition, pursues a course entirely different from the Group II fractures

## SUMMARY OF GROUP II

TOTAL CASES TREATED 35 OR 14 PER CENT OF ALL INJURIES OF WHICH TWENTY-TWO ARE ADEQUATE TO REPORT

Group II.....	Op. under 24 hr.	Op. 4-7 days	Op. 1-6 mos.
Total 22 cases.....	15 cases	4 cases	3 cases
Days in hospital.....	7	4	5
Days in hospital and clinic.....	45	57	70
Motion at clinic discharge.....	50% had full motion	1 full motion	1 full motion
Full motion in remaining cases.....	All in 3-6 mo.	2 at 4 and 13 mo.†	2 at 1½ yrs.
Regeneration of bone at excision site.....	None	3*	None
Average follow-up all cases.....	2 yr. 6 mo.		
Final rating all cases†.....	6 were 3-4-4; 15 were 3-3-4; 1 was 3-3-3†		
Wrist changes.....	None		

\* Three of the four patients operated upon four to seven days developed a regrowth of bone from the radial neck. None of the others did.

† A. 3—Absent radial head; four patients with 5 degree lateral instability of the elbow.

S. 3—Slight pain or weakness with use; bad weather ache.

‡ E. 3—One patient operated upon at one week was followed only six months and had some disability at work and 10 degrees limitation of full pronation and supination.

The dislocating force causes a laceration of the anterior capsule and brachialis muscle. The same force fractures the radial head against the capitulum and drives the radial head fragments anteriorly often through the capsular rent into the substance of the brachialis muscle. Associated fractures of the coronoid process are common. Nerve injuries may accompany dislocation.

Clinically, in addition to the physical signs of dislocation, there is anticubital swelling, tenderness and ecchymosis. These signs warn of torn capsule and indicate an extravasation of blood into the anterior extracapsular tissues. Laceration of the brachialis muscle contributes to this anterior swelling and ecchymosis. The lateral x-ray usually shows anterior displacement of the radial head fragments to a degree greater than an intact capsule would permit. Two patients presented the same physical signs without x-ray evidence of dislocation and at operation a laceration of the capsule and brachialis muscle was found. These reduced dislocations must be recognized clinically by their anterior soft part pathologic disorder. They belong in the Group III category and are treated similarly.

The question may now be asked, "Why

just described. As a group these fractures are predisposed to myositis ossificans. This probably depends upon the combination of hematoma, lacerated muscle and the presence of displaced fragments of the radial head which provide a local source of calcium for new bone formation.

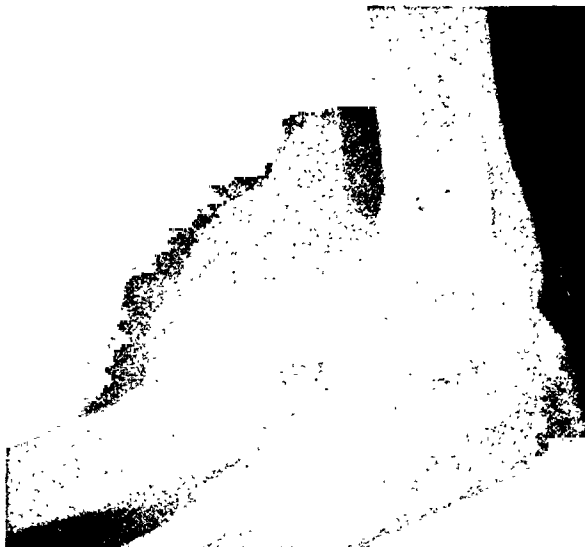
The treatment of these patients is based upon a follow-up study of similar cases treated upon the Fracture Service during the years previous to this report, i.e., previous to 1938.<sup>1</sup> There were twenty patients with anterior extracapsular pathologic disorders. Ten of these were operated upon less than twelve hours following injury and none developed myositis ossificans. The remaining ten were operated upon two to four days following injury and five of these developed myositis ossificans (Fig. 3.) In other words 50 per cent of those patients operated upon after twenty-four hours developed this complication.

The operative approach is considered a factor of importance and one was chosen which would evacuate the hematoma and give ready access to the anterior joint. A transverse skin incision is made across the anticubital space. Vertical incisions form keloid scars which often contract. The interval between brachi-





3A



3B

FIG. 3. A, myositis ossificans twenty-four days following late operation; B, same 3 months following late operation.

oradialis and biceps muscles is separated and the radial nerve gently retracted with brachioradialis. The fibers of the underlying brachialis are separated exposing the anterior capsule and pathologic condition. The joint is further opened and the radial head and fragments dealt with as in Group II fractures. To insure

against fluid tension in the wound area, the capsule and deep fascia are left open and only the skin closed. The transverse scar becomes almost imperceptible with healing.

Pursuing early operation, an average of six hours following injury, and employing the anterior approach on all twelve patients in this group, there was not a single instance of myositis ossificans, a total of twenty-two patients operated upon under twenty-four hours that avoided this complication. The results are summarized in Table III.

The Group III fractures, because they were more severe and were complicated by dislocation, other fractures and nerve injuries, required a longer period of treatment and were slower to regain function. The high incidence of regeneration of bone at the site of excision, 50 per cent of twelve patients, may be a residual manifestation of the tendency to form new bone in this type of injury. It is interesting to observe in successive x-rays taken over a period of years that new bone formation about the radial neck reaches a peak in amount and then gradually begins to recede. This shows the same pattern of increase, plateau and decline observed in myositis ossificans. All six patients show a minimal residual amount of excess bone about the radial neck on last examination.

#### SUMMARY

A total of 261 injuries to the radial head and neck in adults have been reviewed of

*American Journal of Surgery*

#### SUMMARY OF GROUP III

TOTAL OF FOURTEEN CASES, 5 PER CENT OF ALL INJURIES, OF WHICH TWELVE CASES ARE ADEQUATE TO REPORT

Dislocation on admission 10 cases—5 with coronoid fractures

Dislocation suspected and torn capsule and brachialis found at operation 2 cases

Associated injuries 1 compound; 2 ulna nerve palsies; 1 radial nerve palsy

Average time injury to operation 6 hours (1½ to 16)

Average hospital days 15 days (7 to 18)

Average hospital plus clinic days 102 days (62 to 174)

Motion begun 6 days (2 to 23)

Full motion gained 5 cases in 6 to 14 mo.

Average motion in remaining 7 cases 45/170 P & S full except one with S-35 degrees

Average follow-up 3 years

Final rating All (3)-3-4\*

Myositis ossificans None in 22 cases operated early

Regeneration of bone at excision site 6 out of 12 (50%)

Wrist changes None

\* (3) Absent radial head; 2 cases had increased carrying angle.

3 (1) Limitation of motion; full extension minus 10 degrees and full flexion minus 10 degrees in 7 cases (2) bad weather ache; (3) slight pain with use; (4) crepitation with rotation.

which 113 are sufficiently documented to report. All patients presented have been followed a minimum of six months and an average of two years, six months. Three groups are classified according to their essential pathologic condition. Group I comprises 81 per cent, Group II, 14 per cent and Group III, 5 per cent of total injuries reported.

Group I injuries with fracture undisplaced and hemarthrosis the outstanding pathologic disorder are best treated by aspiration of the elbow joint and active motion within pain limits in twenty-four hours.

Group II injuries with fracture displaced and joint capsule intact are best treated by early excision of the *entire* head and early active motion.

Group III injuries with fracture displaced

and joint capsule torn anteriorly by an associated dislocation at the elbow require immediate action. Fifty per cent of such patients operated upon later than twenty-four hours following injury through a lateral operative approach developed myositis ossificans. All patients in this series were operated upon an average of six hours after injury through an anterior approach; all avoided this complication.

Statistical summaries of total cases reported substantiate these views.

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# COMPLICATIONS ARISING IN THE TREATMENT OF FEMORAL SHAFT FRACTURES

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MUCH has been written on the subject of femoral shaft fracture over the past few decades and some of the best known practitioners in the field of fracture surgery have expressed their views in the literature on the subject. Notwithstanding the fact that some of our ablest men with the most mature judgment have given treatment of this fracture their attention, there is a startling division of opinion as to the best method of treatment and marked discrepancies in end result studies of patients treated in similar fashion. Comparative statistical reports vary so greatly that the reader is forced to the opinion that no method is pre-eminently superior to another. The studies indicate the degree of skill exercised in alternative methods of treatment employed by supervising surgeons or surgical group making the report rather than giving a definite answer as to how the rest of us should treat fracture of the femoral shaft.

The very diversity of opinion tells us that this is a problem fracture with no universality of treatment to be prescribed and therefore perhaps profitable for occasional review even though no new thoughts may be expressed. It is our purpose to mention the more common complications arising from various standard methods of treatment and to cover in more detail the complications which occur in this fracture no matter how treated.

Probably the most venerable of modern methods of therapy is that of external fixation by means of a plaster cast. This of course implies a proper reduction followed by adequate and prolonged fixation in a double leg plaster spica. This was the course of treatment so ably followed by Willis Campbell<sup>3</sup> and Robert Jones.<sup>9</sup> Complications arise from this form of treatment as with all others. The general trend away from the use of the plaster spica is recognition of the fact that many complications arise from the prolonged rest of such a large portion of the body. These may be such things as the general retrogression of the physi-

cal status, mental deterioration, thrombophlebitis, renal calcinosis and development of pressure areas.

Complications may arise, however, in the plaster cast treatment of this particular fracture. A well reduced position may be lost during application of the cast. Finally there may be loss of alignment and even overriding after an originally adequate reduction and immobilization due to pull of heavy thigh muscles. It still remains a satisfactory form of treatment in the hands of those aware of its possibilities and liabilities.

Another way of handling this injury may be described as the pin and plaster method by which reduction and fixation is accomplished by placing pins in the shaft of the femur above and below the fracture site and after reduction has been accomplished to maintain the position by bolting the pins together or incorporating them in a plaster cuff. Such a method has been described by Moore<sup>13</sup> and advocated by Anderson<sup>1</sup> and others. Complications peculiar to this method of treatment consist of improper placement of pins with possibility of soft tissue damage, infection of pin sites, loosening of pins or bars or softening of the plaster cuff resulting in loss of an adequate position. We do not personally advocate its routine use but it does have an appeal for the occasional patient whose physical or mental status demands an ambulatory form of treatment.

Probably the most commonly used form of therapy for this fracture is traction. Most writers claim adhesive skin traction to be unsatisfactory although Kidner<sup>10</sup> claims good results with its use. Some men use Russell's traction for treating this injury.<sup>5,15</sup> The majority of men employ Kirschner wire skeletal traction and report good results when carefully supervised. There are advocates of both the transcondylar placement of the pin or wire and those who by choice prefer tibial tubercle placement. Our own preference is for the latter since we believe we can obtain better alignment

of short distal fragments and at the same time have no difficulty with the knee joint which could be blamed on the traction. Swart<sup>20</sup> advocates double wire traction for the longer distal fragments which are difficult to control.

Complications arising from the use of pins or wires may be listed as improper placement of the pin, breakage of pin and infection of pin site. It need hardly be pointed out that the joint itself is to be avoided and that placement of pins and wires is an operating room procedure. Complications arising from the use of traction are chiefly two. One arises from the use of too little weight in the first few days of treatment when traction is used as a means of reducing the fracture. It is our practice to anesthetize the patient and manually reduce the fracture if this has not been accomplished by traction in twenty-four to forty-eight hours. The second complication occurs after a few days of treatment from the use of too much weight when traction is used as a means of maintaining reduction. The great thigh muscles gradually lose their tonus permitting distraction of the fragments.

A fourth method of treatment used for femoral shaft fracture is reduction by operation and internal skeletal fixation followed by external protection for a period of time by casting or traction. There are few reports in the literature from writers advocating open reduction as the primary method of choice. Sherman<sup>16</sup> was a great believer in operative fixation but stated that at that time there were perhaps a dozen hospitals in the United States in which this could be safely done by routine. The late Clay Ray Murray<sup>14</sup> read a paper advocating this method of treatment but qualified his advocacy with a number of "if's" so that the average surgeon would hesitate to follow this dictum in the average hospital.

More typical perhaps is the attitude of Funsten and Lee<sup>7</sup> that operative fixation should be an unavoidable necessity rather than a treatment of choice. There is, however, a latitude of opinion as to what constitutes necessity. This revolves around the question of what is a satisfactory alignment and when one should intervene in a delayed union. These two controversial subjects are not easily resolved by precise definition but must be individually answered out of experience of the surgeon handling this type of problem. All agree that suspected soft tissue interposition requires operative reduc-

tion. Some writers show that the percentage of patients having complications is greater in the operative group and that the possibility of complications is greater than in those treated by closed methods. Complications we have seen include sepsis, breakage of plates, loosening and breakage of screws, improperly placed incisions and inadequate protection following operations. Thrombophlebitis and pseudarthrosis are likewise reported. Some statistics claim to show delay in union as a result of operation.

This hastily reviews the usually accepted methods of treating this fracture together with a listing of complications peculiar to the method of treatment. Four complications common to this fracture will be considered more fully.

*Behavior Problems.* While not ordinarily considered as a complication in the treatment of this fracture, it is our experience that this factor all too frequently interferes with the successful conclusion of a planned method of therapy and is responsible for prolonging the end result as well as contributing to a poor result. We have seen no statistical evidence presented in any series of case reports attempting to evaluate this factor and its influence upon the time of healing and on the final function. Many authors make comment that in a certain patient in their series a bad result was obtained because of lack of cooperation or interference in the course of treatment on the part of the patient.

We have noted emotional misbehavior fairly often in this group of individuals. It may take a mild form such as the anxiety state or emotional lability down to loss of interest in food and surroundings, uncooperativeness and even truculence. A true psychosis is not infrequently seen while mental aberrations among older age groups is not uncommon. Most of us can remember days when fracture of the femoral neck and trochanter was treated by prolonged casting. There were always a few older women going slowly mad until the disturbance they created necessitated the removal of the plaster spica.

It is our impression that these mental problems are seen more frequently in the casted patient but they are encountered whatever the form of treatment. We think it may be useful to assess the patient's mental and emotional status before embarking on any plan of therapy in an effort to make the adjustment before rather than in the midst of a committed course. This is not always possible for most of these



FIG. 1. Patient was a forty-five year old white steel worker who fell 45 feet and received pin-point compound fracture of femur with dislocated shoulder treated at first by traction. A, shows position at first operation six months after injury; B, appearance four months later after a fall in the harbor; C, reoperation, replating and tibial onlay graft; D, four months after reoperation.

individuals get into difficulties only after weeks of treatment. For this we have nothing better to offer than psychotherapy and a change of treatment if advisable. Under these circumstances one anticipates a poor end result.

We include x-ray pictures of one such patient who was previously treated by skeletal traction but who was uncooperative so that the fracture was overriding and unreduced. The fracture was then openly reduced and fixed with a plate and multiple chip grafts laid around the fracture site. After many weeks the patient was so abusive and difficult to handle that hospital authorities would no longer keep him and he was discharged with an ischial weight-bearing brace. One night a few weeks later he was pulled out of Boston Harbor as the culmination of a celebration with some friends. As a result of this episode the plate was bent, screws loosened and angulation of the fracture site occurred. (Figs. 1A to D.)

*Refracture.* That fractures of the femoral shaft show a tendency to refracture has been remarked upon by several writers. This is particularly true in the series of war wounds reported by Stuck and Grebe<sup>19</sup> and by Brav and Fitts.<sup>2</sup> These are, however, a specialized group of patients, many with compounded injuries actually or potentially infected, on whom the early treatment was dictated by meager facilities at hand and by the necessity for early transference from one hospital to another.

Even in reports of simple fractures found in civilian practice the incidence of what is called refracture is high enough to be disturbing so that McMurray<sup>12</sup> raised the question as to whether or not these fractures of the femora were taking longer to heal now than formerly. Watson-Jones and Coltart<sup>23</sup> replied that there was no difference in the healing time of this fracture but that nowadays there is a better



FIG. 2. A, view of femur five months after plating and three weeks after removal of plate at another hospital; B, femoral shaft plated and tibial onlay graft in place; C, seven months after plating and grafting.

roentgenologic checkup of patients so that our criteria of healing is more exacting. Textbooks in general have been guilty of minimizing the healing time for this fracture. The same authors report the incidence of refracture commonly in the eighth to tenth weeks. Soto-Hall and Horwitz<sup>17</sup> report the average time of refracture in their series to be seven and a half months from the time of injury. Eliason and North<sup>6</sup> report refracture in five patients in their series, the time element ranging between four and sixteen weeks from the time of injury.

To our mind the word refracture implies a fresh fracture at a site which has already healed or in which the healing process is about completed in the repair of a previous fracture. If this is generally true, the word refracture is a poor choice to describe this condition. It is obvious from the literature that most authors contend the bone has never healed from its original fracture and that this entity is a loss of position in a bone which has not yet healed. It is an inescapable conclusion that refracture is associated with poor judgment as to the healing time of this fracture. Most writers say that this occurs in three to four months. This is the exception, however, and not the rule particularly if we keep in mind the time of refracture in patients with refracture reported by Soto-Hall and Horwitz.<sup>17</sup> We agree with McKeever<sup>11</sup> that criteria for satisfactory healing is obliteration of the fracture line with re-establishment of bony trabeculation.

Figures 2A to C are illustrative of refracture in a thirty-nine year old woman injured while skiing. The femur was plated and the plate removed five months later. We first saw her three weeks after this with a refracture which we treated by replating and bone grafting.

*Knee Stiffness.* Another troublesome complication of femoral shaft fracture is stiffness of the knee. This is reported following all forms of treatment and represents a real challenge to the surgeon.

McKeever<sup>11</sup> reports 82 per cent of his patients treated with traction could flex the knee to a right angle or better whereas only 59 per cent had this amount of motion following internal fixation while results were poorer still with external fixation.

VanGorder<sup>22</sup> reports stiffness of the knee in eleven out of forty-three adult patients followed, and the average arc of motion in these patients was 76 degrees.

Eliason and North<sup>6</sup> noted that six of their seventy-three patients had stiffness of the knee, how much is not recorded, and stated that all six of this group were treated with reduction and casting. One of these was a child. In a discussion of this paper Campbell,<sup>3</sup> an advocate of this form of treatment, said that his patients were not troubled with knee stiffness.

Stuck and Grebe<sup>19</sup> in their series in soldiers report that twelve or 10 per cent had motion of less than 90 degrees, a good record for the type of cases they were supervising, and attribute

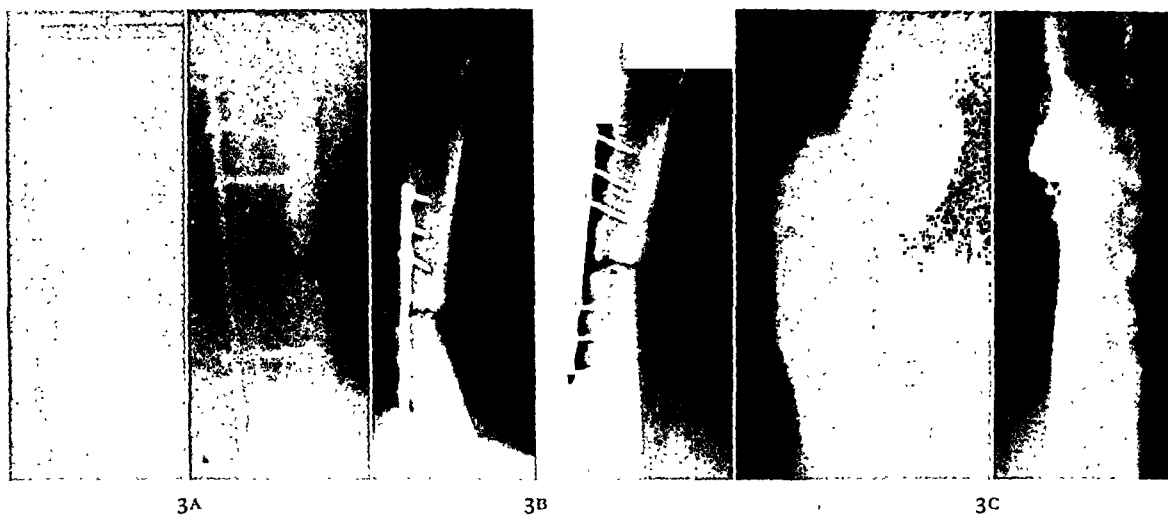


FIG. 3. A forty year old male run over by a truck was treated with Kirschner wire traction and spica; fracture was plated six weeks later; patient first seen by us one week after with temperature. A, postoperative plate; screws do not extend through both cortices; wound sepsis present; B, two and one-half months after plating; following this examination plate and screws were removed; C, view twelve months after injury; quadricepsplasty performed three years after injury.

the favorable results to the age group of patients they were treating together with early quadriceps exercises and early operation when indicated.

It will be concluded from the above reports that knee stiffness is a fairly common complication of this fracture but there is a wide diversity of opinion as to which method of treatment carries with it the greatest threat of subsequent fixation. Watson-Jones<sup>23</sup> states that immobilization of a normal joint or well placed traction through a normal joint is not responsible for subsequent stiffness but rather it is due to anchorage of the quadriceps apparatus by initial soft tissue injury or infection.

Charnley,<sup>4</sup> in an analysis of thirty-four patients reported, concludes that adhesions of the quadriceps is the greatest cause of stiffness and reports good results from quadricepsplasty.

Our own practice is to start quadriceps setting exercises early and to pursue active and passive knee exercises when healing of the fracture permits. This is continued for months if necessary so long as any improvement is noted.

In two patients has the Thompson<sup>21</sup> quadricepsplasty been performed. Figure 3 shows the fracture suffered by this patient. His arc of motion before operation was 5 degrees and after operation was 70 degrees. The second patient was Case 1 already reported. He had an arc of motion of 5 to 10 degrees before and 100 degrees after operation.

*Delayed Union.* It is admittedly difficult to define what should be considered a delay in healing time of this fracture. From what has already been quoted the normal healing time is reported variously by different authors. Furthermore the location of the fracture may influence the rate of repair. Funsten and Lee<sup>7</sup> state that fractures of the lower third tend to heal faster than fractures at other sites. One can only make a general statement that the average healing time is long at best. If we consider this to be five months, failure to heal somewhere in the five- to seven-month period may be considered delayed union.

There are of course time honored reasons for delay in union. Distraction of fragments from too much weight and angulation or overriding from ill-conceived traction are universally accepted. Other causes of slow union are found in delay in initiating treatment and failure to protect the limb until union is complete. An example of this factor can be seen in the x-rays of Case iv. (Figs. 4A to C.) She was a twenty-two year old girl with emotional instability treated initially in another hospital. The surgeon's note states that the reason for operation was lack of cooperation in Kirschner wire traction. Our first contact with her was six months after injury at which time the plate was broken and shaft angulated with melting of callus. She was re-plated and bone grafted finally obtaining a solid repair.

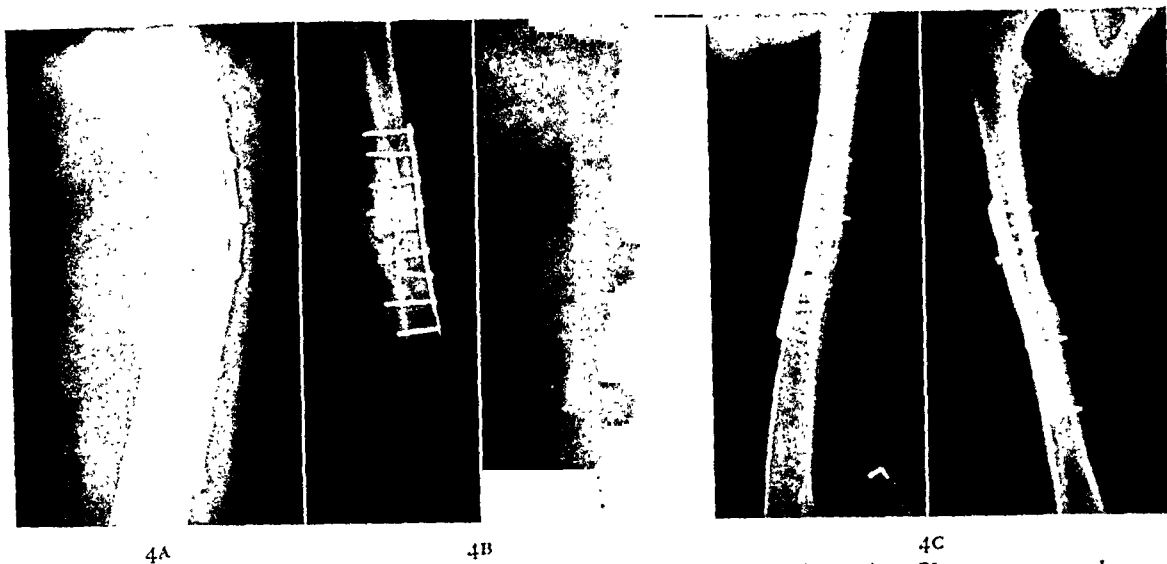


FIG. 4. The patient was struck by an automobile and treated with skeletal traction. She was operated upon, plated and placed in a plaster spica. This was done in another hospital. A, view when first seen six months after injury with broken plate and melting of callus; B, reoperation with bone plating and tibial inlay graft; C, six months after reoperation. Case IV.

At the time of sustaining a fracture there are two common causes for delay in union: one is interference of the local blood supply, an assumption difficult to prove, and two is the interposition of soft parts. Most authors agree that the latter condition requires operation. Case V shows the x-rays (Figs. 5A to C) of a twenty-two year old clerk whose femur was fractured when struck by a steel beam. When first seen by us four months after his injury, there was a thin ribbon of callus on the medial surface with a well established gap between the bones which had been present since his admission x-ray. While traction may have been a contributing factor, it was suspected that there was a soft part interposition and we operated upon him. This was found at operation and the material was carefully curetted out trying to avoid the ribbon of callus already present. The gap was filled with bone chips and an inlay tibial graft laid down.

A point of disagreement appears to be the effect of open reduction on the healing time. Funsten and Lee<sup>7</sup> state that the outcome is improved and complications fewer with closed reduction. Soto-Hall and Horwitz<sup>17</sup> record no great difference in healing time between open operation with fixation and closed reduction. Ghormley and his group<sup>8</sup> reported operating in 32 per cent of their femoral shaft fractures and state that a slightly longer time is required for union in this group of patients. On the other hand Watson-Jones and Coltart<sup>23</sup> think that

if open reduction is properly and carefully performed there is no contributing cause for delay in union. Infection of a compounded injury or infection introduced at time of operation is always a cause of delay in union.

Our own belief is that in the past when plating alone was done we could anticipate slow union in these fracture cases. As will be noted in some of the x-rays reviewed we have run the gamut of inlay grafts, onlay tibial grafts, iliac grafts and have recently used bank bone as a source material. Our preference at this time is for a massive onlay graft of tibial bone with the packing of bone chips all around this area with fixation accomplished by a bone plate. When this is properly performed, we have not noted delay in union.

In reviewing the opinion of authors over the years it is only fair to state that newer tools and technics may have modified their original opinions. Certainly the influence of some of the newer metals, use of antibiotics, intramedullary nail and the concept of the role of cancellous bone in producing faster repair are all measures which make an impact on this problem. However, we find ourselves in agreement with Kellogg Speed<sup>8</sup> that in spite of all the newer aids which come along an intelligent grasp of and energetic use of the fundamentals of fracture treatment will be found to make the greater contribution to the successful handling of this fracture.





FIG. 5. A, shows fracture site four months after injury while being treated in skeletal traction; B, at operation the ribbon of callus was saved and fracture line crossed by tibial onlay graft and bone chips; C, view four months after grafting. Case v.

#### SUMMARY

1. Four of the usual methods of treatment of femoral shaft fracture are discussed as follows: (1) reduction with external plaster fixation; (2) pinning with external bar or plaster fixation; (3) traction and (4) operative internal skeletal fixation.

2. The more common complications which arise as a result of each method of treatment are mentioned.

3. Complications of this fracture common to all forms of treatment are discussed as follows: (1) behavior problems and their influence on end results; (2) refracture and its avoidance by adequate and prolonged protection; (3) knee stiffness, its incidence and control and (4) delayed union and its more common causes.

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# MECHANICAL PROBLEMS IN OPEN REDUCTION OF FRACTURES

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**M**ANY mistakes are made in the type of plate and screws used and in the method of application of these in the

small which may result in placing excessive torsional stress on the screw at the junction of the head and shaft or may cause pressure necrosis within the screw hole. The screws may not be inserted perpendicularly to the axis of the bone. In a recent case because of the presence of screws which broke during the post-operative observation of a patient who had an open reduction done at Beekman-Downtown Hospital, we submitted the removed plate and screws to a metallurgist. A brief outline of the treatment of this patient is presented followed by remarks based on the metallurgic report giving reasons why internal fixation in this patient resulted in failure.

## CASE REPORT

J. G., a forty-eight year old male, was admitted to Beekman-Downtown Hospital on July 25, 1946, suffering from the following injuries: fracture of left patella, fracture of middle third of shaft of left femur, fracture of mandible at symphysis, ascending ramus and condyle and concussion of brain. On admission he was placed in Russell traction (Fig. 1) with 10 pounds of weight preliminary to open reduction and internal fixation. This was delayed because of the poor general condition of the patient and concomitant injuries. On August 6, 1946, twelve days after admission, the patient was operated upon at which time a  $5\frac{3}{8}$  inch 18-8 SMO stainless steel six screw plate and three transfixion screws were inserted. (Fig. 2.) The patient was then placed in Russell traction with a 4-pound weight. The operative wound healed primarily. The post-operative course was uneventful. Quadriceps exercise was started fifty-five days postoperative, being delayed because of the fractured patella on the same side. X-ray film taken ninety-three days postoperatively showed some callus. At this time opinion was expressed by some of the staff that there was some bending of the plate. On December 4, 1946, 119 days postoperatively, traction was discontinued. There was no further bending of the plate and the screws were in good condition. On December 7, 1946, he was allowed to sit up in a chair. On December 23, 1946, he was fitted with a non-weight-bearing caliper, allowed up on crutches and discharged on December 24, 1946. He was

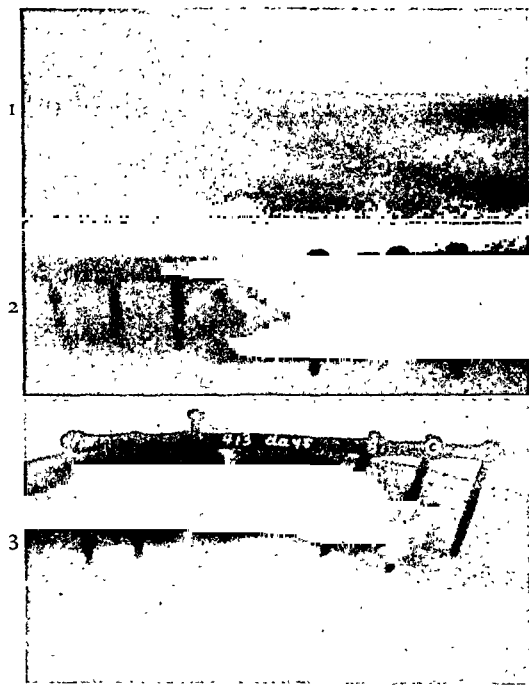


FIG. 1. Fracture of shaft of femur day of accident; in Russell traction.

FIG. 2. Fracture of femur after internal fixation.

FIG. 3. Four hundred thirteen days after internal fixation; screws A, B and C have broken; two others have pulled out. The plate at its distal end has separated from the bone. In later figures A is marked 1; B, 4; and C, 5.

fixation of fractures. For example the plate may be too short, improperly curved or marred before or during the operation. The screws may not be made of the same material as the plate and the flutes may be too long lessening holding power. The threads may be poorly cut or filled with metal filings. The screws may not pass readily through the holes in the plates. In application the drill may not be centered in the plate hole. The correct size of drill may not be used so that either there is lack of holding power if too large or excessive torque if too



FIG. 4. A, section of improperly curved plate on section of human femur; B, section of properly curved plate on section of human femur.

followed periodically in the fracture clinic until September 29, 1947, when he was readmitted because of an ununited fracture and condition of screws and plate as revealed by x-ray. (Fig. 3.) On October 11, 1947 (fourteen months, six days after the operation), the plate and screws were removed and a new plate inserted in addition to iliac bone chips being placed around and between the fragments. He was placed in Russell traction until November 1, 1947, when a plaster body spica was applied. When seen last on May 10, 1949, he had union at the fracture site. He was walking without the aid of any appliances.

Why did screws B and C break in the middle of the medulla? According to the metallurgist there was no evidence of corrosion of either the plate or screws. Evidence of corrosion would certainly have been present if there had been any appreciable electrolytic action between them during the more than fourteen months that they remained in contact with each other exposed to the body fluids. Chemical composition and hardness must be the same or corrosion will take place. The plate and screws used on a patient should come at least from the same manufacturer if not from the same lot of steel. The chemical composition and hardness of the plate and screws were sufficiently alike to preclude electrolytic corrosion in this case.

The screw holes in the plate had been punched (not drilled) after the plate was curved so that they were fairly round. That has not been true of some other plates examined from the same manufacturer. Further, the screws were of sufficiently small diameter (0.1347 to 0.1355 inch) to pass freely through the holes November, 1949

in the plate. That also has not been true of some other plate and screw combinations examined from the same manufacturer.

The grossly insufficient curvature of the plate was the primary cause of the trouble. The transverse radius of curvature of the wide portions of this plate ranges from something over  $\frac{3}{4}$  inch to something over 1 inch instead of the specified value of  $\frac{3}{8}$  inch. (Fig. 4A and B.) As a consequence the edges of the plate were not in contact with the bone and it offered no resistance to the forces tending to rock it. These were resisted only by the transverse stiffness of the screws which are not designed to carry such stresses. Other specimens of grossly insufficiently curved plates supplied by the same manufacturer have been removed because of fatigue failure of some of the screws. Such a plate should never be used but all the plates from army stock which this metallurgist examined were grossly deficient in this respect. It means that the plate is in contact with the bone along the line of the screws only and not at the margins.

At 175 days postoperatively all except the outermost layer of the proximal cortex under screw A (Fig. 3) was still dense. The bending stresses in the screw caused by rocking of the plate were thus concentrated close under the head where the fatigue failure occurred. At the time this x-ray was taken both the proximal and distal cortices around the last screw had lost much of their density so that this screw had already lost most of its holding power.

At 231 days the second screw distal to A had started to come out. B and C showed definite absorption in the proximal cortex

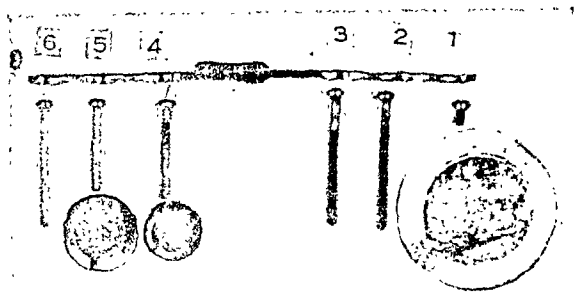


FIG. 5. Plate and screws with enlarged photographs of the broken ends of screws 1, 4 and 5. These show (most plainly in 1) the transverse markings characteristic of progressive failure under repeated excessive bending stresses caused by the plate rocking on the bone. The burring of the threads is shown on screw 3.

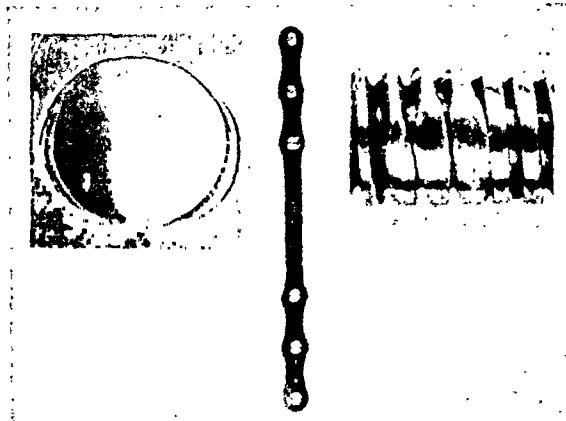


FIG. 6. Plate with enlarged photographs of part of screw and screw hole 3 showing extreme burring of the threads of the screw and the edges of the hole.

but no absorption in the distal cortex. The proximal cortex under the heads of screws B and C at the time the x-ray was taken had already lost much of its density and resistance because of the excessive forces which acted on it. As a consequence the bending stresses in these screws were concentrated in the portion of the screw in the medullary cavity close to the still dense distal cortex. This accounts for the location of the later fatigue failure in these screws.

At 282 days B and C showed advance of absorption but were intact. At 336 days there was further advance of absorption about B and C. Most distal screws show more absorption in distal cortex. At 413 days A, B and C were broken and the distal portion of the plate separated. (Fig. 3.)

The breaks in the three screws marked A, B and C are typical fatigue breaks caused by rocking of the plate on the bone which produced repeated flexural stresses in the screws which remained fixed in the distal cortex but became loose in the proximal cortex. (Fig. 5.) Although plates so grossly defective in transverse curvature are an invitation to fatigue failure of the screws, it has not always happened when such plates have been used. It is possible that failure might not have occurred in this case if the screws had been more accurately centered in the holes through the plate. Examination of these holes shows that all of them have been burred and deformed by rubbing against the screws either when the screws were inserted or after the plate became loosened. (Fig. 6.) This is confirmed by the observation that some part of the threads of all except one of the seven screws sent to the metallurgist were burred.

In other patients, in some plates which were removed because the screws became loose burred holes and burred threads on the screws were noted which were believed to have been inserted through the burred holes. In some of these there was no doubt that the burring was caused by inserting the screw in a pilot hole in the bone which was not concentric with the hole in the plate.

The edges of the slots in the heads of all the screws were upset and marred and gouged by the blade of the screwdriver. (Fig. 7.) The marring and gouging are presumably to be explained by slipping of the blade in the slot but the upsetting can only be explained by the application of excessive torques in inserting or tightening the screws. The excessive torques may have been made necessary because of pilot holes in the bone too small for the screws or because they were not concentric with the holes in the plates.

Excessive torques in tightening the screws do not increase their holding power but actually decrease it by exerting undue pressure on the bone. It is even possible to use sufficient torque in tightening the screws to break off the threads cut in the bone and completely destroy their holding power. No more torque should be used than is necessary to seat the head of the screw snugly in the countersink in the plate. However, no corrosion was found about any of these heads.

This metallurgist has been worried to think that there were sure to be more failures from the same causes with their concomitant reoperations, prolonged hospitalization and even poorer final results. Even if defective plates



FIG. 7. Enlarged photographs of the slots of the six screws showing burring and upsetting.

and screws are not used, trouble can be caused by faulty technic in applying perfectly good plates and screws. Dr. Leonard T. Peterson's article<sup>1</sup> in addition to describing good technic points out some common faults in application. It does not, however, emphasize the seriousness of the results which can be caused by such faults.

#### SUMMARY

Some of the various mechanical problems in open reduction of fractures have been mentioned. A case has been presented in which a plate loosened, screws broke and non-union occurred. We believe this was due primarily to use of a plate with insufficient curvature the rocking of which caused fatigue failure with breaking of the screws. This rocking also caused loosening of some of the screws. The burring of plate holes and screw threads suggests that the screws may not have been centered in the plate holes accurately. The upsetting of the slots in the heads of the screws means that excessive torque was used in inserting or tightening the screws. To obtain the desired result greater attention needs to be given to the basic details of choice of and application of plates and screws.

#### REFERENCE

1. PETERSON, LEONARD T. Fixation of bone by plates and screws. *J. Bone & Joint Surg.*, 29: 335-347, 1947.

DISCUSSION OF PAPERS BY DRS. KERNWEIN AND CAMERON, HAMMOND, BUTLER, GASTON, SMITH AND BAAB, MORRISON AND ADAMS, AND KENNEDY AND STONE

JAMES J. CALLAHAN (Chicago, Ill.): Dr. Kennedy is to be congratulated for bringing such an impor-

tant paper to our attention. With the exception of errors in technic in the application of the plates, we have already experienced the serious complication of having the screws and plates break.

I would like to call your attention to another fact, that is, the drill point which frequently breaks after multiple sterilizations. Recently the manufacturers have been trying to improve the material and quality of the drills and I believe the Collison drill at the present time is probably the best. While it will not break, it will bend and thus not hold a sharp edge. In fact, after three to four sterilizations it becomes very dull.

A point I would like to emphasize is that we frequently find broken drills in the bone following surgery. I think we should make an effort to remove the drills when broken instead of leaving them in. I know that I have been guilty of this habit but in recent years I have tried to remove any drill that is broken. There is a little apparatus similar to a trephine that assists in removing the broken drills.

A general plea should be made to the manufacturers to make better metal plates and screws. In a review of many of the plates and screws it was found that they were defective either in the flutes, threads or that the depression of the head was either too deep or not deep enough. In other words, they were not uniform or to specification.

It is hoped that Dr. Kennedy's constructive criticism will do much to eliminate the defect now present.

G. EDMUND HAGGART (Boston, Mass.): I personally feel indebted to Dr. Kennedy for bringing the fact home to me that insufficient transverse radius of curvature of the wide part of the plate is of such significance.

I wish, however, to ask him a question. I have the penny test down all right but is that on the whole quite adequate to settle that particular point? Secondly, what suggestion may he have as to how we could check our screws other than our own observations? Are there any special precautions we could utilize?

I am in complete accord with Dr. Callahan about the bits. They have been a source of considerable distress to us.

Finally, I was impressed with the point Dr. Kennedy made in this particular case of his. There was no electrolytic action whatsoever so that it was apparently a mechanical fault essentially in relation to this inadequate curvature of the plate.

In conclusion I would like to say again what the previous speaker just mentioned; that is, it is well and better than that to emphasize the distressing results that occur from improper application and inadequate training in utilizing such internal fixation.

GEORGE J. CURRY (Flint, Mich.): I wish to make a few remarks about the presentation that has been given by Dr. Gaston. The principles that he has outlined are very basic and the follow-up studies most convincing. They are characteristic of the efficiency of the Presbyterian Hospital Fracture Service.

I reviewed seventy-five consecutive radial head fractures extending over a period of four years and the evaluation of these cases is very similar to the classification that Dr. Gaston has presented. Eighty per cent of them were non-displaced, consisting of the type of fractures that he demonstrated in his first illustration. The remaining 20 per cent were displaced fractures.

The rationale of treatment of the non-displaced types in our community with many doctors taking care of fractures of this sort has been the reverse of Dr. Gaston's presentation. Fixation of the elbow at 90 degree flexion in various types of fixation apparatus, i.e., a posterior mold or a light circular plaster or a sling for a week or two was the method of choice. Early active motion was urged. That seems to be a pretty good policy in a hospital where you do not have the exact and efficient follow-up that is so characteristic of the service that Dr. Gaston represents. The results were good for the most part, complete function returning in a few weeks to a few months. Joint aspiration was done in a few cases in which pain was an important factor.

Displaced fractures indicate removal of the radial head. The two types have been mentioned together with the technic advised. This opinion is universal.

I would like to ask Dr. Gaston two questions. When do you call a fracture of the radial head displaced? What are your criteria? What would you do with that last bad case that you showed in group III if it came to you at two weeks? Would you take out the radial head then or would you wait? And if you waited, how long would it be?

I would like to compliment Dr. Gaston for an excellent presentation.

J. HUBER WAGNER (Pittsburgh, Pa.): I have been asked to discuss Dr. Kennedy's presentation. I think that he has brought out the essential facts

regarding the use of the proper plate and screws so far as the centering of the hole in the plate and so far as the screws are concerned.

During the war, of course, the manufacturers of these plates were not very careful as to the making of the screws and many of them were burred. If the screw is burred, a simple test for this, as asked for by one of the gentlemen, is to take one before you use it and put it between your thumb and forefinger. If it rolls smoothly and there is no catching on the skin when held loosely, you will find it is not burred. If it is burred, of course, it is going to ram out the hole that has been originally placed by the drill.

As to the drill size, of course, one should be prepared before one attempts to do any plating to make sure that his drill is at least one sixty-fourth smaller than the screw he intends to use if he expects to get any purchase.

In the particular case that Dr. Kennedy presented I think, first, there was a very poor choice of plate. He brought out the improper curvature. That is a factor. There have been many flat plates used with excellent results but, mechanically, the proper curved plate is the one that gives the better holding and should be used. In this case, too, the plate was too short. If I read the x-ray properly, there were two fractures of the femur and the upper fracture had no fixation whatever. Is that not where the non-union took place?

The external fixation after the internal fixation was improper as one could see. The stress was on the upper screw. It pulled out and then the fatigue strain naturally came on the other two screws. It was purely mechanical.

KELLOGG SPEED (Chicago, Ill.): At the risk of having the hammer pulled on me again, I would like to introduce at this time the fact that there is a revision about to be attempted in our nomenclature of fractures. Committees have been appointed from various surgical bodies to attempt a complete and searching revision of all the forms and types and so forth.

In that connection if we care to call the fractures at the lower or distal end of the radius all by one name, that name should be pronounced properly. The name is not "Collès." The man's name was pronounced Kólez with the accent on the first syllable.

BOARDMAN M. BOSWORTH (Bronxville, N. Y.): I was particularly interested in Dr. Gaston's group III cases with reference to myositis ossificans. The reasons for the occurrence of myositis are the reasons usually given, namely, the raising and tearing of the periosteum and infiltration of the muscles with hemorrhage.

I would, therefore, like to have Dr. Gaston explain to me why early operation will obviate the occurrence of ossification later. As I recall he said that in the operation which he does the fascia is

not closed but the skin is. How can this obviate the underlying disorder? I would also ask him to tell us what he does when the myositis has occurred; how does he treat those cases?

With reference to Dr. Adams' paper, which I very much enjoyed, I used to be a Roger Anderson enthusiast in the early days and I became very anxious to use these pins in the femur. I used them in just one case. That turned out to be a terrific headache, about the worst result I recall having had on my hands.

JAMES K. STACK (Chicago, Ill.): I would like to discuss Dr. Butler's paper. I enjoyed it very much.

However, I think he is in some instances too radical. The subject of arthritic change in the wrist following non-union of the navicular with subsequent ulnar displacement of the lunate as necrosis takes place has interested me for a long time. In the *Annals of Surgery* for August, 1948, there is an article reviewing the results of the excision of the proximal row of the carpus for this condition in which we believe that it is a worth while procedure and much better than fusion of the wrist in these selected cases.

When arthritic changes take place following necrosis of one or both fragments of the navicular, the greatest change occurs on the radial side. You all know of the osteophytic spike that occurs at the styloid of the radius; only a minor change will take place in the early cases in the really important part of the articular surface of the radius so that the navicular, both fragments, and the lunate may be removed and the capitate or the os magnum will come down in a matter of ten days or two weeks and give what we think is a very satisfactory wrist. Of course, there will not be a complete range of motion but it has not been our experience in the cases that have been well chosen that these people have prolonged pain or weakness.

In two of our patients, this was done bilaterally. One patient was a railroad fireman who is still working and another was a dentist who is still practicing. You will grant that one must have a reasonable degree of stability, painlessness and strength in order to accomplish this.

There is no other place in the body where we can get such good conditions for an arthroplasty. The cartilage of the os magnum or the capitate is usually undisturbed and only minor disturbances have taken place on the articular surface of the radius so that it requires no interposition of fascia or synthetic material. Furthermore, the patient is protected from then on against the cystic and arthritic change that would otherwise occur over a period of years.

We have cases that have been seen for as long as thirty-five years, and those which were reported were followed for not less than ten and for as high as thirteen years. I commend this procedure to you, therefore. It is something that at least should

be thought about because the average patient will shy away from any procedure which requires the stiffening of a joint and we can give them a reasonable range of motion the other way.

LAURIE H. MCKIM (Montreal, Quebec): I wish to take just a moment to compliment Dr. Gaston, the author of the paper on fractures of the head of the radius, on the excellence of his paper and also to make a few inquiries.

I understood Dr. Gaston to say that he operated upon all of his patients, when possible, within twenty-four hours. He also stated that 50 per cent of all those operated upon after twenty-four hours developed myositis ossificans, better known as calcifying hematoma. The statement was also made that 50 per cent of all patients developed bone at the site of excision of the head of the radius. These statements are in such startling contrast to the figures of the group with which I have been associated that I would like to know if there is a common factor that is the cause of the difference.

It has been our custom not to operate in the first twenty-four hours but rather to operate at the end of four to five days when things apparently had quieted down a bit. Secondly, we have been in no hurry to start movement in the first twenty-four hours or anything near it but rather at the end of a few days and then only within limit of pain.

I have yet to see in one of the cases handled in that manner bone development at the site of excision of the head and I have yet to see my first calcium hematoma in those cases. Therefore, I would like some discussion of this question of the early or late operation as has been brought out also by Dr. Bosworth.

As to the other point (physiotherapy), the late Dr. Fraser Gurd used to state that when he was asked the question when he would refer any elbow case to the massage department, he said, "Any time after the eighth month." That was merely his way of impressing people with the idea that you did get calcifying hematoma around the elbow joint following early movement.

I would like to ask a second question of Dr. Gaston. Did the patients who developed this amazingly high percentage of calcifying hematoma and new bone formation have early massage?

The third question is, what per cent of those minor fractures in which the head was not removed but early movement was started developed calcifying hematoma?

HENRY C. MARBLE (Boston, Mass.): I would like to discuss briefly the phonetic spelling of the name Colles. The gentleman in question deserves consideration. We pronounce his name in two syllables. Whether you call it Collēs or Colles, the main thing is that he did pronounce his own name in two syllables. He wrote one article on fractures in his entire life and that is the article we all know. I am going to visit the shrine of the great Irish



surgeon next fall and if I can find any of the Colles family in existence, I am going to take my dictaphone and have them inscribe on a wax cylinder, in proper phonetic enunciation, exactly the way that we Americans should pronounce the name in the future.

FRANK E. STINCHFIELD (New York, N.Y.): I would like to say a few words about the first two papers. Dr. Kernwein presented a most interesting series of spine fusions in which metal screw fixation was used. I am sure that he is basically correct when he states that the end result must be judged not so much on bony union but on the presence or absence of pain and the patient's ability to return to his former occupation.

However, it would seem that a word of caution should be interjected regarding internal fixation in spine fusions. Technically it is not too easy to insert the screws in the ideal position. Also a great deal of holding power is being required of a relatively small facet area. The long leverage arm above the area of fusion exerts a tremendous force on the short leverage arm produced by the screw fixation. Physiologically and anatomically, it does not seem right to do a spine fusion and have the patient out of bed in twenty-four hours or within the first two weeks.

Three years ago we became very enthusiastic about early ambulation of patients having had spine fusions in which screw internal fixation had been used. Our percentage of pseudoarthrosis rose precipitously, coincidental with an increase in recurrence of back pain and disability. In a large series of reported end result studies of spine fusions it was found that 50 per cent of pseudoarthroses were asymptomatic.

The only way to tell accurately whether or not a pseudoarthrosis exists is to obtain flexion extension and lateral bend x-rays. The conventional anteroposterior and lateral stereoscopic views frequently fail to show a definite pseudoarthrosis.

Dr. Kernwein has presented an excellent paper and his results speak for themselves.

Dr. Hammond presented an exceptionally fine method of dealing with the comminuted Colles' fracture and one which will be of benefit to all. His results as shown and stated leave little to be desired.

In a comminuted Colles' fracture one must exert traction and countertraction to effect the reduction and then must maintain these forces until enough new callus forms to prevent recurrence of deformity. I know of no satisfactory, comfortable, safe way of accomplishing this other than by the use of wires.

At times we have varied the technic as described by Dr. Hammond. Rather than extending the plaster above the elbow to effect countertraction, we have placed a wire through the olecranon and, after reduction has been accomplished, include both wires and yokes in the circular plaster. In

this manner the elbow is left free to move. Since the method as described by Dr. Hammond has been used, the end results have been greatly improved.

It was a pleasure to hear both of these excellent papers. Thank you.

GRAHAM A. KERNWEIN (closing): I wish to thank Dr. Stinchfield for his remarks. I am aware of the work to which he refers but I reiterate that it differs from our experience. We find that with early ambulation patients get up, return to their occupation, do their usual work and state they are comfortable.

The question of whether or not a pseudoarthrosis is present is more academic than practical. The fundamental question is whether or not the patient has been relieved of pain and can he do his work. We find the vast majority can.

GEORGE HAMMOND (closing): I wish to thank Dr. Speed and Dr. Marble for their discussion of the proper pronunciation of the C-o-l-l-e-s fracture. I am sure that we will all be anxious to hear Dr. Marble's report on the pronunciation next year.

I wish to thank Dr. Stinchfield for his remarks. Elbow joint motion in the elderly patient has not been a problem with the treatment as outlined. It was surprising to me that these elderly patients mobilized their elbows so easily and quickly after the long arm cast was removed.

A. A. BUTLER (closing): I would like to thank Dr. Stack for his remarks. I listed ten indications. He has criticized one, so on the basis of that, I assume he agrees with the other indications.

This question of arthroplasty of the wrist is one that I have looked into a good deal and I have seen good results with it but not for the cases of fractures of carpal scaphoid in which we have gross osteo-arthritis involving the entire carpus. That is a different group, I think, from the ones to which Dr. Stack is referring.

In the R. A. F. we estimated that we had over 800 fractures of the carpal scaphoid and that over 200 of these were seen at too late a stage to produce a good functional result. That group plus the group in the subsequent three years represents a very large number. There have been twenty-one cases in which the gross osteo-arthritis has been severe enough that we have considered it necessary to do an arthrodesis.

Our indications are not very wide, so that I think if we analyzed our cases, Dr. Stack and I would probably agree on these. I did show one illustration of an arthroplasty, excision of the proximal row of the carpus, in which the patient had a stiff and painful wrist that required arthrodesis.

R. H. KENNEDY (New York, N.Y.): May I ask one question before Dr. Gaston closes the discussion? I understood him to say that the excision of the head was done proximal to the orbicular attachment. I would like to ask him if I understood him correctly.

SAWNIE R. GASTON (closing): That is correct.

I appreciate very much the interest which has been shown in this paper and wish to thank the discussers. I thank Dr. Curry in particular for his generosity. In answer to his question about what comprises a displaced fracture, I tried to avoid in the article a metric definition thinking that it might be better if we had a functional concept of the duty of the proximal radio-ulnar joint in terms of its circumferential pivotal anatomy. If a fragment is sufficiently out of place to interfere with rotation, flexion or extension, the head should certainly be removed. However, if we are to choose a metric definition of displacement, let us say that if more than 25 per cent of the articular surface of the head is separated or displaced more than 2 mm., that head should be removed.

In answer to the second question proposed by Dr. Curry, what would one do with a fracture in the group III classification seen first by the surgeon two weeks after injury, I think it would be best if that elbow were not operated upon. I think every effort should be made to gain as much function as possible by active motion. If, after four months, motion was still limited and the patient was complaining of symptoms, and if by x-ray there was no evidence of early myositis ossificans, I think that the head could be removed at that time. If there is evidence of myositis ossificans, I think it would be very unwise to operate before a year or possibly two. Judgment would depend upon x-ray evidence of the increase in the amount of calcium present by successive examinations; and when the amount of calcium has appeared to reach a stationary level and then begins to decline in amount, it would be safe to excise en masse the antecubital calcification.

In answer to Dr. Bosworth's and Dr. McKim's remarks about the myositis ossificans, I know of no explanation why bone forms in the soft tissues. I don't think that problem has ever been elucidated to everyone's satisfaction. Whether it is in the muscle of the thigh or any other part of the body, it is a mystery. We do know enough about bone healing, however, to know that the acid pH of the blood is of some consideration and that the presence of a local source of calcium in the form of bone fragments is of consideration as are also lacerated muscle, fascia and periosteum.

Why operate in twenty-four hours? This situation of potential bone-forming elements is eliminated in large part by immediate operation. The fascia is left open so that the tissue fluid and tension in the antecubital fossa can be decreased by leaking out and possibly that may have some bearing in terms of pH that discourages bone formation.

GORDON M. MORRISON (closing): Dr. Kennedy and Dr. Stone are working on a problem that certainly interests me because in the last year I have had at least six screws break. I am more than

grateful to these men and I hope they keep up the good work.

If I might say a word about Dr. Gaston's paper which I admire very much, I would like to add that his remark that the decision to operate or not to operate must be immediate, is certainly a good thing for us all to remember. The sad results that we have had have all developed from changing our minds three or four or six weeks after the original injury.

Concerning the paper Dr. Adams gave, I am coming to believe that on femoral shaft fractures that are to be plated perhaps we would do best to put on a massive bone graft as a primary affair in the first place and be done with it.

MEYER M. STONE (closing): On behalf of Dr. Kennedy and myself I want to express our appreciation for the kind remarks made by Drs. Morrison, Haggart, Wagner and Callahan. It certainly is an incentive to go on with this type of work.

With reference to Dr. Haggart's remarks about screws and how one can determine whether a screw is good or bad, Dr. Wagner gave us some hint about that when he said: "Roll the screw between your fingers and see if any burrs or filings are in the threads." If there are, the screw should be discarded because it will ruin the hole drilled in the bone. If the flutes are unusually long or irregular, the screw should be discarded. I have examined flutes in some screws that ranged from  $\frac{1}{8}$  to  $\frac{3}{8}$  of an inch in length with marked irregularity. They limit the holding power of the screw in the distal cortex if that screw is not passed beyond those flutes in that distal cortex. The screws should fit loosely through the holes in the plates and thus prevent any contact with the sides of the plate and cause flattening of the threads as they go in.

Dr. Wagner made the remark that our plate was too short in this particular instance and that there were two fractures. Let me correct him if I may. There was but one fracture and a loose fragment. The loose fragment was held by three transfixion screws and the plate applied after the loose fragment had been fixed.

As to the length of the plate, the one used was the longest plate that was available at the time in an 18-8 SMO. We certainly believe that a longer plate might have given us better results. That is a matter that is open to question and we believe that failure here is primarily due to the radius of curvature of the plate being entirely too large.

In reference to Dr. Callahan's remark on the drills, he is perfectly correct in saying that the Collison drill, as is used by us at the present time, does not break but bends and dulls rather quickly. A broken drill point should not be left in, that is, the usual high-speed drill, because it is a dissimilar metal as compared with the composition of the plate and screws. This may result in setting up an electrolytic reaction with an adjacent screw or the plate which we have seen occur.

# FARM ACCIDENTS

## A CLINICAL AND STATISTICAL STUDY COVERING TWENTY YEARS\*

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ONE hundred thousand needless accidental deaths occur in the United States each year. Four thousand five hundred of these, the greatest number of occupational deaths in the country, are among farmers.<sup>1</sup> For every fatal accident there are approximately 100 serious, disabling but non-fatal agricultural injuries which often require weeks of hospitalization and months of convalescence before rehabilitation is complete.

This report is based on a review of 658 accidents of this type during the years 1929 to 1948 inclusive. The patients were treated at the Mary Imogene Bassett Hospital in Cooperstown, a medium-sized general Hospital equipped with all facilities for modern diagnosis and therapy. A previous survey of farm injuries from this institution<sup>2</sup> was published for the years 1929 to 1938 and the data from this earlier report are included in the present survey. Subsequent to the initial report from Cooperstown, Creevey published a similar study from the Mary McClellan Hospital in Cambridge, New York.<sup>3</sup> Since the methods of farming in this area are similar to those in the central part of the state, Creevey's statistics have occasionally been utilized for additional comparisons.

### ANALYSIS OF 658 FARM ACCIDENTS

*Incidence.* During the first decade embraced by this study (1929 to 1938) 1,329 patients with serious injuries from all types of trauma were admitted to the Bassett Hospital; 310 of these, or 23.3 per cent, were related to the hazards of farming. During the second decade (1939 to 1948) there were 1,805 admissions due to accidents, of which 348 were agricultural, an incidence of 19.3 per cent. During both decades farm accidents were responsible for 20.9 per cent or one-fifth of all admissions caused by trauma. Only 34 per cent of these patients received professional care before arrival; 17 per cent were given some first aid by laymen and 49 per cent had no medical attention.

*Seasonal Distribution.* Curves representing the seasonal distribution of all farm accidents during each of these two decades are similar and also are quite comparable to the curve for all rural accidents (Fig. 1) reported at the Conference on Rural Medicine in Cooperstown in 1938.<sup>4</sup> The peaks during July and August are composed largely of accidents due to haying, those which occur during the repair and construction of building and those in which children are involved while at play around machinery in operation, men at work, farm animals and buildings. Accidents in the course of routine chores are fairly constant throughout the twelve months while those due to logging occur most often during the late fall and winter. Summer is obviously the most dangerous season on the farm, late winter and early spring the most secure.

*Location.* In the original survey of 310 farm accidents during the years 1929 to 1938 the barn and barnyard were found to be the most dangerous localities on the farm. (Fig. 2.) Accidents on the highway did not include mishaps to farmers as pedestrians or while riding in motor vehicles for pleasure but were limited to those which transpired during hours of work with animals or farm machinery. A few accidents occurred in the farm house and shed, 6.8 per cent, which should perhaps be more properly designated as "home accidents on the farm" rather than strictly "farm accidents."

A very close correlation was found among the 348 accidents during the years 1939 to 1948. Related sites have been grouped and are tabulated for comparative study in Table 1.

*Etiology.* At least two factors participate in the causation of most farm accidents, a motivating activity and a causative agent. In this analysis of etiologic factors the cases reported by Creevey from the Mary McClellan Hospital have been included with those from the Bassett Hospital and bring the total number available for study to 1,028. The data are

\* From the Department of Surgery of the Mary Imogene Bassett Hospital, Cooperstown, N. Y.

presented in tabular form and include both the number and percentage of accidents in each series which were induced by each activity and caused by each agent. (Tables II and III.)

or suicide" may be questioned as a hazard of farming but the authors believe that both are occasionally induced by the lonely life of poverty and solitude which many farmers lead

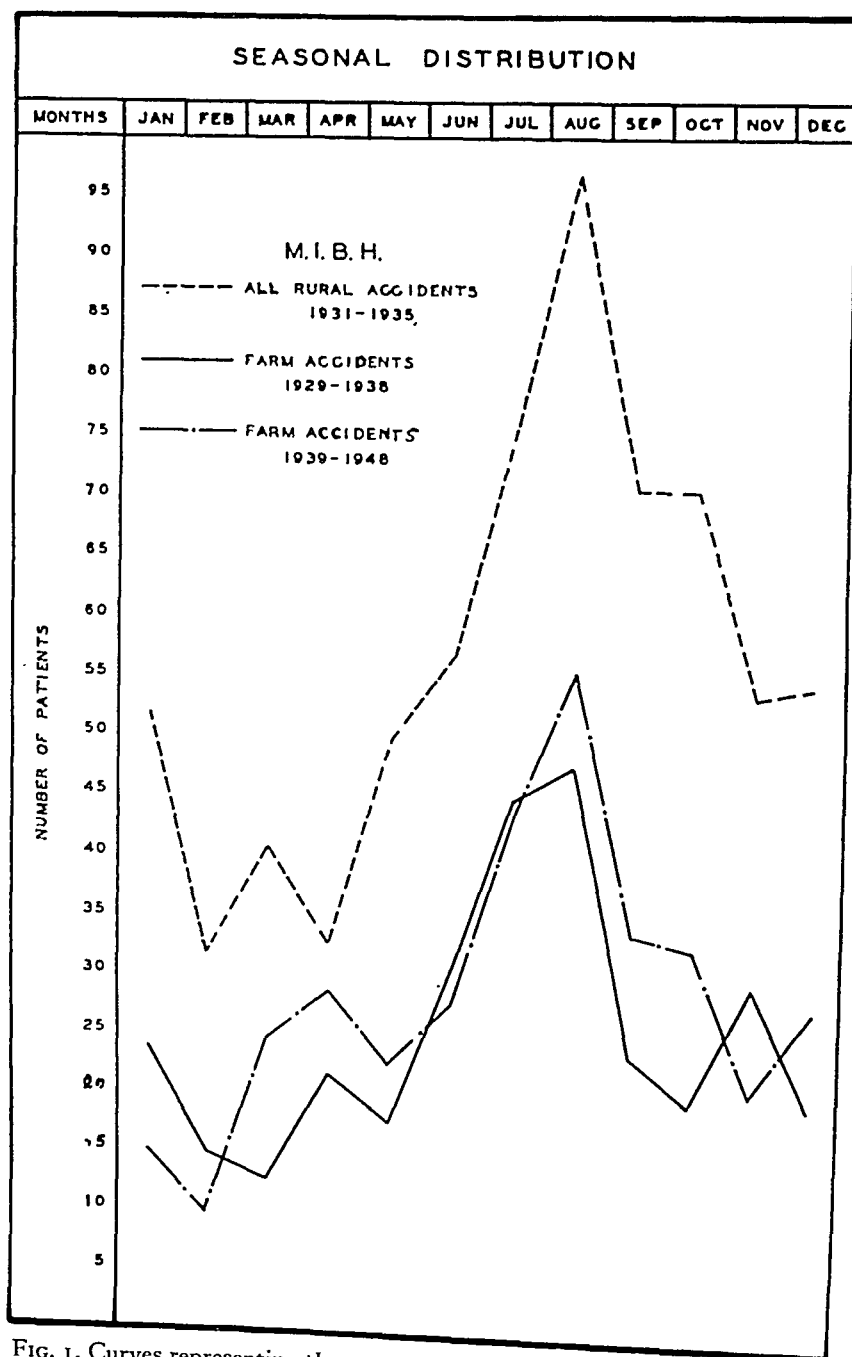


FIG. 1. Curves representing the seasonal distribution of farm accidents during the decades 1929-1938 and 1939-1948 compared with the seasonal distribution of all rural accidents from 1931-1935.

Routine farm chores were responsible for about one-third of the 1,028 accidents (Table II), logging and haying for one-sixth each. Approximately the same number were sustained by children while at play. "Assault

in distinctly rural areas and so should be included in this survey.

The etiologic agents are recorded in Table III. Farm animals were responsible for the largest number in the total series. Three-

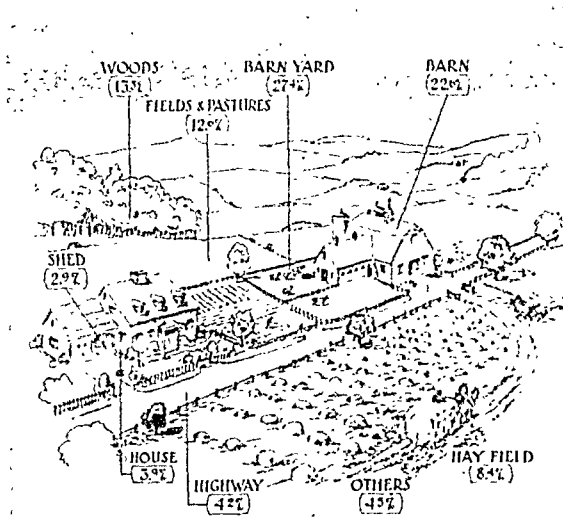


FIG. 2. Illustrates the location of 310 farm accidents during the decade 1929-1938.

fourths of these were caused by horses; one-fourth by cows and bulls. Tools and implements were the offending agents in 15.7 per cent of the injuries, the axe and pitchfork most often

TABLE I  
LOCATION OF FARM ACCIDENTS\*

Scene of Accident	Per cent of Farm Accidents		
	M. I. B. H.		
	1929 to 1938	1939 to 1948	Average
Barn or barnyard.....	50.0	51.6	50.8
Fields and pastures.....	21.0	22.1	21.5
Woods.....	13.5	8.5	11.0
House and shed.....	6.8	8.1	7.5
Highway.....	4.2	4.7	4.4
Others.....	4.5	5.0	4.8
Total.....	100.0	100.0	100.0

\* Comparative tabulation by decades of the location of 310 accidents during 1929 to 1938 and 348 during 1939 to 1948. The frequency with which accidents occurred in the same localities on the farm during these twenty years is impressive and significant.

responsible. Approximately the same number of accidents was caused by farm machinery of which the rotary buzz saw is by far the most mutilating.<sup>5</sup> Under "Others" are included barbed wire fences, rusty nails, splinters,

thorns, hooks, chains and firearms. When a fall occurred with no obvious causative agent responsible, none was recorded; the numerous falls on slippery, icy ground account for the high percentage of accidents in the category of "Others or None."

TABLE II  
ETIOLOGIC ANALYSIS OF THE MOTIVATING ACTIVITY IN 1,028 FARM ACCIDENTS\*

Etiologic Activity	M. I. B. H.				M. McC. H.		Total	
	1929-1938		1939-1948		1920-1939			
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Chores.....	99	31.9	87	25.0	129	34.9	315	30.6
Logging.....	66	21.3	64	18.4	51	13.8	181	17.6
Haying.....	50	16.1	62	17.8	52	14.1	164	15.9
Play of children....	31	10.0	62	17.8	73	19.7	166	16.1
Repair and construction of buildings...	22	7.1	9	2.6	12	3.2	43	4.1
Assault or suicide...	13	4.2	5	1.4	16	4.3	34	3.3
Others.....	29	9.4	59	17.0	37	10.0	125	12.1
Total.....	310	100.0	348	100.0	370	100.0	1028	99.7

\* Two series from the Mary Imogene Bassett Hospital (1929 to 1938 and 1939 to 1948) and one from the Mary McClellan Hospital (1920 to 1939).

TABLE III  
SIMILAR TABULATION OF ETIOLOGIC AGENTS

Etiologic Agent	M. I. B. H.				M. McC. H.		Total	
	1929-1938		1939-1948		1920-1939			
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Tool or implement....	56	18.1	57	16.4	49	13.3	162	15.7
Animal.....	51	16.5	64	18.4	50	13.5	165	16.0
Machine.....	40	12.9	39	11.2	58	15.7	137	13.3
Vehicle.....	36	11.6	35	10.0	29	7.8	100	9.7
Falling tree.....	17	5.5	18	5.0	16	4.3	51	4.9
Heat or cold.....	7	2.2	2	0.6	21	5.7	30	2.9
Others or none.....	103	33.2	133	38.2	147	39.7	383	37.2
Total.....	310	100.0	348	99.8	370	100.0	1028	99.7

*Analysis of the Accident to Admission Interval.* The length of time required for injured farmers in the surrounding countryside to reach the hospital after an accident has occurred may be influenced by the season of the year, the condition of the roads and the distance to be traversed, the availability of transportation, the severity of the injury and the attitude of both the patient and

his doctor, if any, toward the necessity for hospitalization.

The solid black line in Figure 3 published previously represents the rate of admission during the decade from 1929 to 1938; the broken line represents the same for the subse-

were most frequently injured in rural accidents. This type of curve, indicated by the solid black line in Figure 4, has previously been reported by Powers and Creevey and represents the usual age-distribution of accidents on the farm. The curve representing the age-

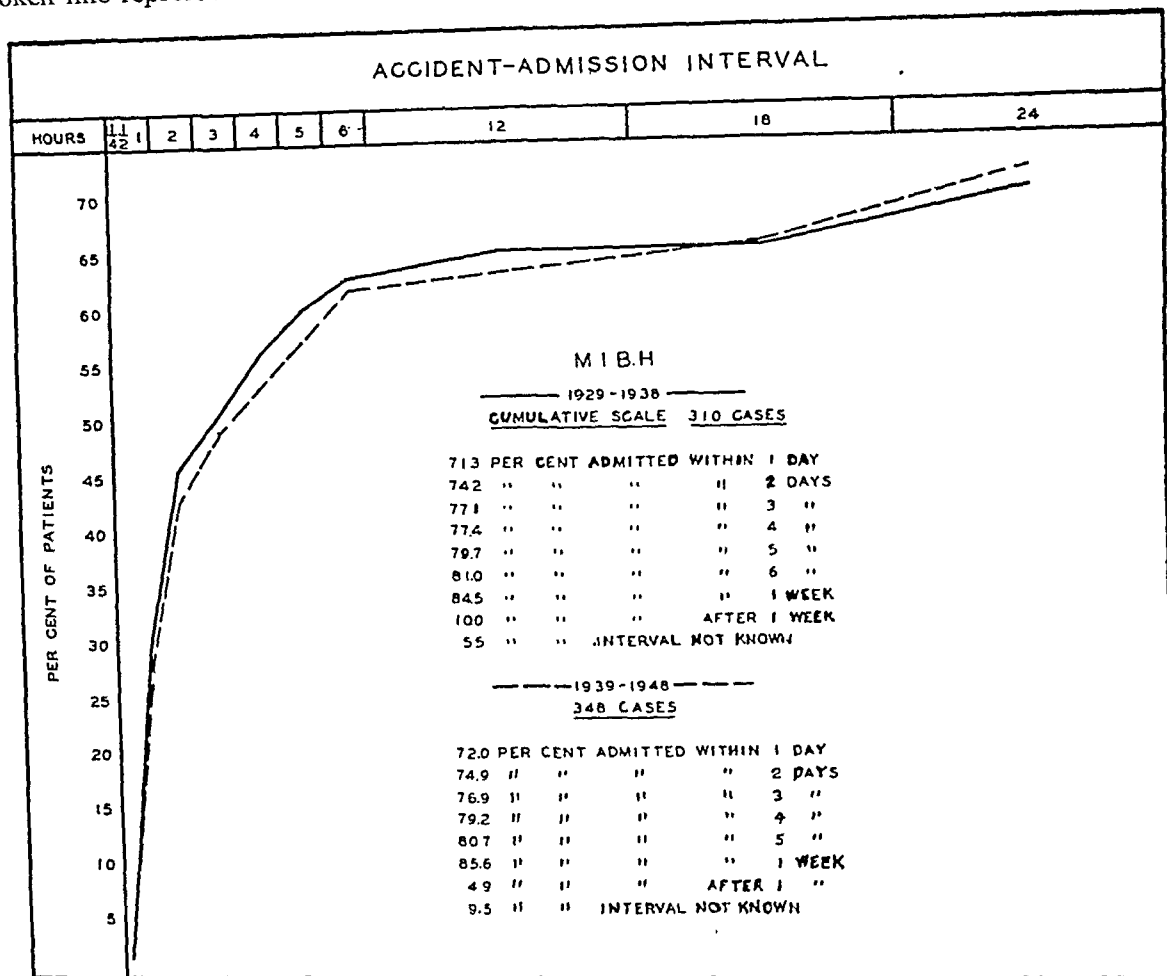


FIG. 3. Graphic analysis of the interval between accident and admission to the Bassett Hospital during each of the two decades in the survey.

quent ten years. It is interesting that in spite of the many variables mentioned previously the two curves can be almost superimposed. Numerous improvements in rural living during the second decade have not been reflected in the rapidity with which farmers in central New York are admitted to the Hospital after injury. During both decades approximately 30 per cent arrived within one hour, 45 per cent within two hours, 55 per cent within four hours and 62 per cent within six hours. The percentages for subsequent intervals from one day up to one week are tabulated in Figure 3.

*Age-Incidence.* During the years 1929 to 1938 farmers between the ages of ten and fifty

incidence during the subsequent decade from 1939 to 1948 shows very distinct variations from the normal. This period embraced the war years when men between the ages of twenty and twenty-nine had left the farms for the armed services and many of those between forty and forty-nine were more profitably employed in munition plants and other essential industries. Many of those between thirty and thirty-nine years of age who were unfit either for military duty or industrial labor were capable of farm work and obtained agricultural employment while those between the ages of fifty and fifty-nine who in normal years would have retired continued at work to

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supplant younger men in the services and war plants. These suggestions may serve to explain the dissimilarity in the curves representing the age-incidence of farm accidents during the first and second decades of this survey.

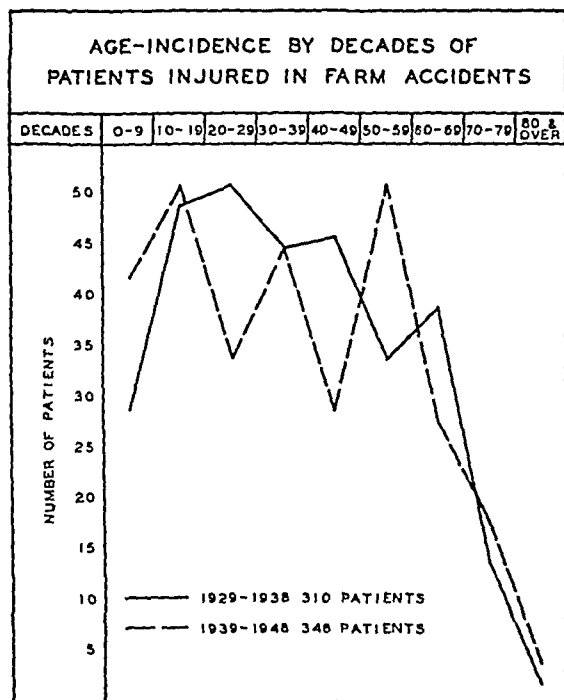


FIG. 4. Graphic representation of the distribution of farm accidents according to the ages of the patients injured. The reason for the dissimilarity of the curve for the years 1939-1948 when compared with that for the previous decade is suggested in the text.

**Classification of Injuries.** During the twenty years from 1929 to 1948 the 658 patients treated at the Bassett Hospital as a result of farm accidents sustained 1,527 recorded injuries classified according to the Standard Classified Nomenclature of Disease. These are listed and tabulated in order of frequency in Table IV. In actual numbers there were 488 fractures of which 134, or 27.4 per cent, were compound. Lacerations were next in frequency. Division of nerves, tendons and blood vessels and partial or complete amputations of fingers, hands, forearms and legs were common and were due to contact with rotary saws, mowing machines, ensilage cutters, scythes and axes. Punctures were caused by hay forks, manure forks, rusty nails, barbed wire fences, thorns and splinters. The upper extremities were injured most frequently, the lower extremities last.

**Period of Hospitalization.** During the first decade embraced by this study, 1929 to 1938, the average period of hospitalization as a result of farm accidents was 18.3 days; during 1939 to 1948 the average was 14.1 days, a

TABLE IV  
TABULATION OF 1,527 RECORDED INJURIES IN ORDER OF  
FREQUENCY OF OCCURRENCE

Classification	Per cent of Farm Injuries		
	M. I. B. H.		
	1929 to 1938	1939 to 1948	Ave. 1929 to 1948
Fractures.....	33.7	30.0	31.7
Lacerations.....	14.5	14.0	14.2
Divisions or amputations....	10.6	5.9	8.2
Contusions.....	7.8	6.2	7.0
Incised or punctured wounds	7.4	6.6	7.0
Abrasions.....	6.1	4.9	5.5
Concussion.....	4.1	5.7	4.8
Dislocations.....	4.1	4.1	4.1
Burns or frost-bites.....	3.5	2.4	2.9
Shock.....	2.1	1.1	1.6
Compressions.....	0.6	0.7	0.7
Gunshot wounds.....	0.6	1.1	0.9
Foreign bodies.....	0.5	2.4	1.4
All others.....	4.3	15.0	9.9
Total.....	100.0	100.0	99.9

decrease of 23 per cent. This represents an average of 4.2 days per farmer-patient, a distinct saving in both time and money. Open reduction and internal fixation of fractures, the liberal use of chemotherapeutic agents and antibiotics and prompt ambulation whenever possible after injury have been responsible for the current modifications in convalescent care.

**Analysis of Fatalities.** During the years 1929 to 1938 there were sixteen deaths among 310 patients admitted to the Bassett Hospital because of injuries sustained in farming.<sup>2</sup> (Table V.) During 1939 to 1948 there were three deaths among 348 patients. Two of the patients who died were moribund on admission; the third death was due to massive pulmonary embolism.

The very gratifying improvement in the mortality from serious farm injuries during the years 1939 to 1948 may in part be attrib-

uted to a more thorough understanding of the physiologic alterations in the human economy effected by severe trauma, to the greater availability of blood and substitutes therefor, the extensive use of chemotherapeutic agents and

of their bills and approximately 57 per cent discharged their financial obligations in full. Nine per cent of the bills were paid by compensation insurance carriers and 6 per cent only by the Blue Cross or similar organizations.

TABLE V  
TABULATION OF STATISTICS RELATIVE TO MORTALITY FROM FARM ACCIDENTS

1929 to 1938, 310 Patients

Cause of Death	No.	Contributing Activity	No.	Contributing Agent	No.
Fracture—dislocation of cervical spine.....	4	Chores.....	5	Animal.....	3
Compound depressed fracture of skull.....	3	Logging.....	4	Heat (fire).....	3
Extensive burns.....	3	Haying.....	3	Vehicle.....	2
Multiple injuries and shock.....	2	Children at play.....	2	Falling tree.....	2
Tetanus.....	1	Repair of buildings.....	1	Machine.....	1
Peritonitis.....	1	Suicide.....	1	Firearm.....	1
Bacteriemia due to staphylococcus aureus..	1			Others or none.....	4
Coronary thrombosis.....	1				
Total.....	16	Total.....	16	Total.....	16

Mortality, 5.1 Per cent

1939 to 1948, 348 Patients

Cause of Death	No.	Contributing Activity	No.	Contributing Agent	No.
Multiple injuries and shock.....	2	Chores.....	2	Animal.....	3
Pulmonary embolism.....	1	Haying.....	1		
Total.....	3		3		3

Mortality, 0.8 Per cent

1929 to 1948, Total Patients 658, Total Mortality 2.9 Per cent

antibiotics whenever indicated and to the employment of anticoagulants for the prevention and treatment of thrombosis.

*Fiscal Analysis.* The actual cost of a serious injury is a major financial burden to most farmers. During the first decade embraced by this study 20 per cent of the patients could pay nothing toward their Hospital bill and professional care. During the second decade, in spite of the improved financial status of most farmers, 21 per cent made no contribution toward the discharge of their professional debts. Local welfare organizations assumed the responsibility in some cases but the hospital was forced to accept a financial loss of about \$15,000 or approximately 20 per cent of the total charges made for hospitalization and professional care incidental to the hazards of farming during these two decades. About 16 per cent of the patients paid a portion

Group insurance for both hospitalization and professional care was offered in this part of New York State in 1941 but has not been generally accepted among farmers.

#### SUMMARY

Six hundred fifty-eight patients with serious injuries due to farm accidents, representing one-fifth of all the admissions caused by trauma, were treated at the Mary Imogene Bassett Hospital during the years from 1929 to 1948.

Such accidents showed a definite variation in seasonal incidence with a peak during July and August for which haying, repair and construction of buildings, and children at play around farm machinery were largely responsible.

Routine chores were the most dangerous motivating activities throughout the year.

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Farm animals, tools and machinery contributed their share of injuries in about equal proportions. Falls were numerous.

Exactly one-half of the accidents occurred either in the barn or barnyard.

Nearly 50 per cent of the patients reached the Hospital in two hours.

Fractures comprised approximately one-third of the 1,527 recorded injuries. Extensive lacerations, division of nerves, tendons and blood vessels, and partial or complete amputation of extremities or portions thereof were common.

The average period of hospitalization was 18.3 days during the first decade of the survey and 14.1 during the second.

The mortality fell from 5.1 to 0.8 per cent.

Many farm patients were able to pay nothing for their hospitalization and professional care.

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#### DISCUSSION

R. A. CALANDRUCCIO (Memphis, Tenn.): The length of time required for the injured farmer in the surrounding countryside to reach the hospital after an accident is affected by many factors, namely, the season of the year, the severity of the injury, the condition of the roads, the distance to be traversed and the attitude of both the farmer and the doctor concerning the need for hospitalization.

Despite these various factors which I have already mentioned that control the rapidity with which the farmer can get to the hospital, the many improvements that have been made in rural living in the last ten years have not been reflected in this rapidity.

The second comment I would like to make in passing is that of accident-proneness which in the last few years has gained much interest, especially concerning automobile accidents and industrial injuries. Our psychiatrists tell us that the accident-prone patient is of a certain psychic makeup, that is, in many accidents mental and physical fatigue

and other external factors are not of importance but, rather, that the patient who is accident-prone is self-centered, usually does not deliberate between impulse and action; in many cases this is based upon a rebellion to authority. We have tried to find whether or not these farmers are accident-prone and if we could do something about it. Naturally, this is a very important problem.

In reviewing the 685 cases in the twenty-year period we were not able to show that these farmers show any indication of accident-proneness. The farmer is usually a very stoic man, one who must deliberate before he plants his crops and, therefore, does not fall into the psychic makeup that the psychiatrist has had planned for us.

I would like to mention one more thing that, unfortunately, Dr. Powers did not have time to mention in his discussion, that is, the fiscal analysis. Many of these farmers try as much as they can to pay their bills in full. Over 60 per cent of the total bill was paid by the farmer. Unfortunately, the farmers had not taken advantage of the various Blue Cross plans which had been offered. In our community the Blue Cross plan was offered in 1940; since that time only 6 per cent of the farmers have taken advantage of the plan.

O. SAMUEL RANDALL (Watertown, S. D.): Mechanized farming, developed so extensively in the Midwest, has not been without its toll of injuries. Injuries have been all degrees of severity, from the most trivial to actual death. In this section of the United States where the farms are quite large at least 85 per cent have mechanized equipment.

The farm tractor has been a factor in many of these injuries, due mainly to carelessness of the individual farmer and also to the failure of the manufacturers to equip these machines with proper safety devices. The farmer uses the tractor in very much the same way as a child uses a tricycle. It is not only used for many actual farm duties but also as an ordinary mode of transportation. This machine is heavy, cumbersome and top heavy and its maneuverability is somewhat limited. With proper care it can do many jobs well but if handled carelessly, can cause much damage in the field, farmyard or on the highway. Just last week a farmer was found dead under his tractor where it had tipped over on him in a ditch along the highway. This is not an uncommon type of accident. Some of the tractors are still equipped with manual starters. Therefore, we see the fractured wrist that was frequent when we started our automobiles in a similar manner.

Tractors have now been given increased speed and are, therefore, used to replace a truck for many forms of hauling such as pulling a wagon-load of grain to market, etc. But for such forms of conveyance they can easily get out of control of the driver and tip over sideways depending on any

unevenness of the ground. Some of the lightweight tractors would turn over backwards and on to the fallen driver when pulling a heavy load up a steep incline. With the added speed and more diversified uses of the tractor and with its ease of getting out of control, more accidents are being seen.

To substantiate our beliefs about certain farm machinery, Doanes Agricultural Service of St. Louis reported in the *New York Times* on May 22, 1949, that much farm equipment is too light, wears out too easily and certain pieces are "unsafe." They stressed the point that much equipment isn't "built to last, and that some of the machinery provided is needlessly dangerous."

The tractor is used to pull and deliver power to many farm machines and for this work it is provided with a power take-off. It is because of this power take-off that we obtain some of our most serious and frequent injuries. The injuries sustained from this mechanism vary from numerous hand, arm and leg lesions to actual death. These cannot occur when the mechanism is equipped with protective devices as most of them are today. However, as is too frequent, the operator takes this device off to make certain repairs and then leaves it off. The accident occurs when the operator comes in contact with this part of the machine while it is running. His gloved hand or trousers get caught and pull the individual into it. This connecting rod revolves at a very rapid rate of speed and if one is not able to extricate himself or if someone does not shut off the machine, he can lose his hand, arm, leg or life. The power take-off is shut off on the instrument panel of the tractor. The operator is always cautioned first to keep the safety device over this mechanism and to shut off the power take-off always before trying to make adjustments. The principle fault lies in the fact that the power take-off may still run even though the tractor is standing still with the motor going. These injuries could be eliminated if the power take-off was automatically shut off when the tractor was stopped. To do this would mean an addition to the sale price of the machine and unless all manufacturers put on the same features, there would be no sale for the machine with the advanced price. The individual operators are not interested in such safety features, not until they have lost a hand or an arm. The individual is not interested in spending money for safety.

For the same reason, the power take-off still running, we have frequent serious hand and arm losses from the corn picker machine that is being propelled by the tractor. The operator stops his tractor, motor and power take-off still running, and gets off the tractor to try to pull a stalk out of the picking rollers. It is usually in the fall of the year and he is wearing large gloves. In trying to pull the stalk out his gloves get caught and his hand and arm are quickly pulled into these rollers. A hand or

arm is amputated before he can pull himself out or have some one turn off the motor.

As I have pointed out before, most of our farm accidents are due to carelessness but the farmer is no different from any other individual in this respect; he has these accidents in spite of all our educational propaganda.

These injuries which are attributed to the power take-off in one form or another are frequent and in most instances quite serious. They can be controlled or practically eliminated by the manufacturers cooperating in some simple safety measures. If the power take-off was automatically shut off as soon as the tractor stopped, the injuries could be reduced to a minimum. An officer of one of the largest farm implement companies told me recently that this could be done for about \$150. As it now stands, these machines are potential death traps.

JOSEPH E. J. KING (New York, N. Y.): In view of the fact that I was born on a farm, worked on a farm and expect to go back, God willing, Dr. Powers' paper was of special interest to me, with his beautiful illustrations, tables and plans. I have sustained every injury he enumerated there except amputation and gunshot wounds.

I will relate two little incidents about farm accidents: The first time I ever heard of a traumatic rupture of the duodenum was in a story related about thirty years ago by the late Dr. W. D. Haggard. He told of a boy about ten years old who was pushing a pitchfork down a path. He hung the pitchfork beneath the root of a tree, jabbed himself in the belly with the end of the handle and sustained a tear or rupture of the transverse portion of the duodenum.

In 1933 at a meeting of the Southern Surgical Association a paper entitled "Arachnidism" appeared on the program. I had not the slightest idea what it meant but from the study of zoology I knew that "Arachnida" meant the family of spiders and the word arachnoid meant like a spider web. I heard the paper and learned that it was about spider bites, the bite of the Black Widow, which subject was most intriguing. The essayist reported five cases and his reason for so doing was that usually the patient was admitted to the hospital and diagnosed as an "acute abdomen."

Several surgeons discussed the paper and reported one or more cases with identical findings. All stated that the pain in the abdomen was most intense and that even  $\frac{1}{2}$  gr. morphine by hypodermic administration did not relieve the pain. They informed us that the abdomen was the most rigid abdomen known to them, accompanied by severe pain but no tenderness. The reason for presenting the paper was to prevent surgeons from operating upon these patients in the belief that an intra-abdominal disorder would be found. All stated that the pain ceases either with or without

operation and all symptoms disappear in about twenty-four hours.

I present this story to you for what it is worth. To me it was most interesting.

JOHN H. POWERS (closing): I was very much interested in Dr. King's comments. Those are, no doubt, some of the hazards of farming in the South.

I am also grateful to Dr. Randall for calling attention to some of the injuries which may occur in an area where farming is mechanized far beyond the point where it is in central New York.

Interestingly enough, the hazards of industry, of mining and of construction have been recognized for many years, and definite measures have been adopted for the promotion of safety. In agriculture no such progress has been made, primarily because

of the individualistic character of farming, especially in smaller communities. The only statistics which have been published, with the exception of two papers, have been based on *fatal* accidents and, in our opinion, these do not present the subject fairly.

I think it would be of extreme interest and real practical value, Mr. Chairman and members of this Association, if, during a period of years, surveys of farm accidents throughout the United States could be made, could be correlated and, possibly in conjunction with the Grange, some constructive steps might eventually be taken to prevent or to reduce the hazards of farming in the United States. It would seem to me to be a worth while, useful and practical project.



# TRAUMATIC NEUROSIS

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ONE of the great and disturbing problems encountered by the surgeon who deals with traumatic patients is the marked incidence of incapacitating emotional states which appear in the patient following, apparently, a major traumatic incident. This problem is large because, frequently, if it is of a major psychotic nature, it may seriously interfere with the actual surgical treatment of the patient or if it is of the so-called "minor nature," it may assume proportions far beyond the actual structural incapacity provided by the physical trauma. There is also the problem of compensation which is apparently quite prominent among cases of this type. An attempt will be made in this paper to discuss some problems which have arisen of this nature and how they were handled, with the hope that the physician who encounters these cases will have a further understanding of methods utilized in dealing with such situations.

## CASE REPORTS

CASE 1. A young mechanic in a large industrial plant came to the plant physician complaining of a severe, prolonged headache and dizziness. He dated the onset of these headaches back to an accident in the plant in which he had been working. Something had gone wrong in the levering process and the bar had snapped against him, throwing him to the ground and knocking his head against the concrete. "I was not unconscious but felt dizzy as soon as I tried to get up." He stated that his headaches began soon after that and he had been almost unable to work. They had been present for about a year's time and had been unresponsive to drug therapy and dietary changes. Neurologic studies by a neurosurgeon and a clinical neurologist were entirely negative. Simple reassurance had failed to help the patient. Psychiatric study revealed the following material: The patient was the youngest of five children, having two older brothers and two older sisters who were all married. The father, also a worker in the same plant as the patient, had gotten his son a job there. The father had considered himself a very religious man. He had attended church regularly, prayed with fervor and taught Sunday school; at home, however, he had been a tyrant who rarely spoke to his wife and when he spoke to his children it was only to reprove

them. He died of pneumonia two years prior to our seeing the patient and approximately six months prior to the time of the accident described by the patient. The mother, equally devoted to religion, was just as incapable of practicing its precepts in her daily life. She, like the father, was never affectionate with the children, never praised them and never took their interests seriously. She seemed to believe that if through scolding, threats or cajolery she could get our patient to church, all would be well. He had completed high school and had been working in the plant with his father up until the time of the latter's death. But his dissatisfaction with life grew and following his accident his headaches made it almost impossible for him to carry on.

The patient was seen in a series of therapeutic interviews arranged at periods of once a week and of approximately forty-five minutes' duration. He soon made clear his hostility toward his father and mother for their unsympathetic attitude. He was particularly angry because they pretended to be so good, "Talking about the love of God, the need for man to pattern his life after the tolerance of Christ and preaching the need of love of one's fellow man." He added, "If they had been that cold and cruel and unfeeling toward others without acting in the name of Christianity, I might have stood it. But the hypocrisy of it all which they could not seem to see nearly drove me mad. When father used to come home from prayer meeting and start scolding, sometimes I would cry to myself; but since he has died and mother goes the same way, I can't cry. I only suffer and hate and get these intolerable headaches." At the point that he said this he suddenly stated, "I wonder if these headaches had anything to do with the accident or maybe, rather if it hasn't got something to do with this business about my father and mother." He was reassured that it would be all right for him to talk about his real feelings and the statement was made, "You really want to get well in order to be able to be happy and comfortable in your work." At this point I would like to note that as regards the neurotic it is true that his symptoms sometimes result in escape from trying situations but this is not known consciously by the patient. Any escape from life which comes through neurosis is dearly paid for by the neurotic in anxiety, physical discomfort, inefficiency and the loss of prestige which results from his inability to keep up in his work and his inability to enjoy life with his fellowmen. In our

patient it became apparent that his social adjustment was poor because all women seemed to him as his mother and sisters had been, that is, "critical, fault-finding and wanting something all the time and having nothing to give." Nevertheless he had a conscious longing for a woman's love although he had masturbation fantasies in which he was cruel to women. He had so much guilt and anxieties about these fantasies that he could speak about them only with great difficulty. We said to him, "Since you believe that women have been cruel and indifferent to you it is natural that you think of retaliation. This retaliation happens to be combined with your sexual feelings and fantasies but do not be distressed too much by this. Speak of it freely and you will see that some separation will take place between your ideas of love and your fantasies of hate."

The patient despised his work and hated going to church and finally got the courage to discuss these attitudes with his mother. She tried to make him feel ashamed but because of his discussions of these matters in an uncritical atmosphere he had gained courage and would not let himself be dissuaded by her. The result was that finally she allowed him to leave home and he got a job in another plant. He liked this better and for the first time his headaches were less troublesome. In the first few weeks of treatment his headaches were so bad that while talking about his parents and their injustices to him he would hold his head in his hands, sway from side to side and beg to be taken to the hospital to have some operation done upon him. "Any operation, there must be something in there, a blood clot or something. My hatred for things that have happened to me is intense but it can't be producing all of this." We urged him to be patient and to keep up the struggle.

After leaving his mother's home he suffered from loneliness from which he sought relief in feminine companionship. These friendships always ended disastrously because he always expected the girl to be kind beyond the possibilities of normal people. He wanted her to be a normal, active, friendly girl and yet make up to him in affection all that his mother had failed to give him. He could not bear to have her ask anything in the way of a favor from him. We said to him, "Remember you have been a deprived person both as a child and as a young man. While you believe that you have missed a great deal and have much coming to you in the way of affection and regard, you must recognize that it cannot be all one-sided. Any girl expects from you a cheerful demeanor and some consideration of her desires. If you can forget yourself a little and think of the girl, you will be rewarded by her gratitude."

The patient finally saw the point of this discussion and at the end of about two years met a girl whom he wanted to marry. By this time his headaches had entirely disappeared and he was reason-

ably happy at his work. He has since married and has been symptom-free and happy.

CASE II. A twenty-eight year old, unmarried young man while serving as an infantryman on the island of Okinawa, had been struck by fragments of a bomb while on patrol. He had lost the entire right frontal lobe and the right eye and had sustained lacerations of the right temporal lobe. He had gone through various hospitals and had been treated with the final, good osmetic result although his right eye was entirely gone. The patient was referred for treatment because of persistent, intense headaches and feelings of inadequacy and inferiority. He was receiving 100 per cent disability from the Veterans Administration and was trying to work in his father's insurance agency. He was constantly fearful that he would blow up in a temper tantrum, get in a fight and be injured in the head.

At the time of his initial study the patient showed no peripheral neurologic signs. Discussion was carefully led into the method of his having been injured. It was found that the patient was the youngest of two children, his older brother having been a commissioned officer in the Army with no combat experience. The patient had entered the Marine Corps at seventeen, had gone overseas and had participated in two campaigns without injury prior to the invasion of Okinawa. Two weeks before the invasion the patient had received word while aboard the invasion ship that his father had died of a heart attack. There were no means for him to communicate with his mother or to return to the United States. He had had to go into the invasion with this knowledge. The patient was quite resistive to coming for therapeutic interviews at first but gradually accepted the relationship. He was constantly hostile and suspicious, however, until I pointed out that probably his suspiciousness was due to his natural feelings in relationship to those in military authority positions and might have something to do with his relationship with his father. He then revealed that his father had been a cold, driving, dynamic and rigid individual who had demanded complete loyalty from his sons and had been utterly unable to give them any warmth, affection or support. The mother, toward whom the patient was deeply resentful but of whom he was quite fond, was a complaining, hypochondriacal individual who had constantly dominated her family through illness. About six months after the initial interview the patient revealed the actual facts of his injury, "I've never told anybody this. It is not a good story but it sounded all right, but you seemed never to have believed it. I've never understood why you didn't because it sounded all right to me, but if you want to know the facts I'll tell you." He was reassured that he could tell them only if he so desired and not because of the therapist's curiosity. It then evolved that the patient despite his prolonged combat experience had impulsively exposed himself on top

of a hill during a mortar barrage a few days after the campaign had started. "I don't know why I did it. I knew better than that but suddenly it seemed to me that I wanted to stand up and run toward them and destroy them all." As the patient talked about his troubles with his parents he became more and more convinced that his injury actually had something to do with his relationship to his father. Finally he found that he did not have to work in his father's insurance agency which had been left to him but that he could pursue his own field which was law and so emancipate himself from the ties of his mother without injuring her.

His headaches have subsided considerably except when he gets in a tight situation with a teacher whom he considers to be non-understanding, cold and demanding. It is probable that this man will eventually be able to accept his own hostility toward his father and his intense guilt feelings which apparently led to an aggressive suicidal attempt on his part during the battle.

To come back to the original questions propounded we can state that we know that these patients have been badly handled previously but can we do any better? What is the matter with them and how should they be treated? In attempting to answer these questions let us quote from a letter received from a young physician who states, "It seems to me extremely doubtful if education of the doctor along these lines is the answer to the problem. To delve into the personality of the patients who need this sort of study requires much more time, tact and patience than most practitioners have, and we cannot refer any considerable number to psychiatrists. Furthermore, as you know, the accessibilities of these facts vary very often with the intelligence of the patient. Even when the emotional set-up has been deciphered you will have to admit that you will find very much the same impasse if you were up against the same situation yourself. In other words, while some doctors may be able to analyze these neurotic factors, generally speaking, very few can alter them, and it has been my experience that understanding a situation has not always turned out to solving it." Last of all let us say that these patients are suffering from disturbances in their emotional lives; that is, the illness is wholly or in part of psychologic origin and can be satisfactorily studied and treated only if this factor is adequately handled. It is too often the major assumption of the physician dealing with the patient that the latter is "only interested in the compensation that he can get" or if he is in military service or in a similar

type of situation "he just wants to get out of it and not assume the responsibility of it." Malingering or conscious utilization of a neurosis as an escape mechanism is a very infrequent pattern. The automatic hostility of the physician toward the patient is the thing that so often blocks the adequate treatment of these conditions. It is true that a simple understanding of the underlying psychopathologic condition does not in itself cure the patient. In other words, besides excluding physical disease in the one patient and correctly evaluating the part it plays in another, it is of greatest importance to know the patient's ability to adjust to certain life situations and his pattern of reacting to them, with the real anxiety in his make-up and the nature and seriousness of his conflict. Psychosomatic study is necessary if we are to establish a specific relationship of the psychic situation to the personality of the individual. Just as the typhoid bacillus, specific for typhoid fever, depends upon the susceptibility of the individual, so does specificity of the psychic event depend upon personality structure of the person. To make such studies one must have some training in psychopathology. One must also know something about the technic of psychotherapy.

In closing let us state that an integrated approach to the study of these patients both from the surgeon and the psychiatrist's standpoint must be carried out without automatic hostility on the part of the attending physician. Too much has been said about the art of medicine with a rejection of the fact that psychotherapy is much more than simple reassurance. It is an attempt to understand the psychologic foundations of the individual personality with guidance and help on the part of the physician that the patient himself may understand his own trends, needs and anxieties. If this approach is possible, it is believed that much of the so-called compensation and medicolegal problems incident to the traumatic neurosis will solve itself in that the patient will not seek that method of protecting his repeatedly injured self-evaluation and pride.

#### DISCUSSION

HENRY C. MARBLE (Boston, Mass.): When this paper which you have just heard arrived in my office about a week ago, my secretary read it—she reads all my mail. When I arrived, she put it down on the desk with a bang and said, "What have you got to do with that?"

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"Got to do with what?" I said.

"That!" she said.

Well I got it out and read it myself and at first I thought somebody was playing a joke on me because when I graduated from medical school, I am perfectly sure that if they had taken a vote as to who was least likely to be a psychiatrist, I would have gotten most of the votes. But then I read it again and I read it again and the more I read it, the more interested I became in it.

Once upon a time I tried to write an article entitled, "What is the Cause of Accidents?" Well, of course, accidents just happen. Before I knew it, I was into psychology so deep that I just had to back out.

Why do accidents happen? Accidents happen because the man is inattentive, the man is thoughtless, the man is angry; the man has something that takes him away from the ordinary course of his daily work and gets him into trouble.

Well, he has an accident and he comes to the doctor. The only part of this with which I want to disagree is that, in my opinion, this is a job for the doctor. A psychiatrist has given it to you but, after all, he is a doctor. In our ordinary practice these cases are just as much a part of the doctor's job as to set a fracture, to sew a wound, to heal the other part. It is just as much his job to know who the patient is and what the problems of the poor fellow down in the bed are. Is his wife going out with the milkman? Is the job going to be open for him when he goes back? Is he going to get his money? What is happening to him now that he is getting \$28.00 a week when he used to get \$100.00?

He is worried and fearful. The element of worry and fear piles up and that poor fellow in the bed is thinking about it. You cannot call in a psychiatrist on all of those cases. I cannot.

All I want to say, then, is that I believe this is the doctor's job. The doctor has to do it and he cannot pass it on to somebody else.

JOHN T. BATE (Louisville, Ky.): In appearing as a co-author I am travelling under false colors as my only claim to authorship is inducing Dr. Trawick to present a paper on post-traumatic psychosis. As the paper developed in the field of post-traumatic neurosis, I do not have any claim to it at all.

I understand that a traumatic neurosis is a defense of the individual to physical threat to his body and it is characterized primarily by withdrawal from the world which is the source of the threat, inhibition of activities and anxiety symptoms. The compensation neurosis is a type of traumatic neurosis in which the secondary gain

from compensation plays an important or even major role. The individual is the product of his heredity, his childhood experiences, his reaction to his adult situation and specifically to the traumatic incident.

The localization of pain to the area of trauma is not a symptom of the traumatic neurosis itself. It is more of an hallucination and may seem very severe to the patient. It is due to the intense fixation of the patient on the site of the injury. The desire for the pain is projected onto a part of the body in a similar fashion to the projection of guilt, love or hate onto other persons in paranoia. In the traumatic neurosis of war the compensation payment desired is relief from further danger and return to family and security.

Dr. Trawick has presented two type cases which illustrate these points. I would like to mention one phase of post-traumatic psychosis as illustrated by the case which aroused my interest in this subject:

A forty-eight year old male was admitted with the following injuries: a transverse fracture of the right humerus, a compound fracture of the left femur, junction distal and middle third, a comminuted fracture of the right tibia and partial amputation of the foot, bilateral.

The wounds were débrided and balanced suspension was applied to the humerus and femur, skeletal traction being used in the latter.

After forty-eight hours he had become completely uncooperative and screamed "Charlie" at the top of his voice almost constantly. This continued for three weeks.

Psychiatric consultation at first indicated that the patient had an underlying psychotic state which was made apparent by the intoxication from barbiturates, bromides and chloral through the relaxation of mental controls. But this did not seem to be the whole story and it was not until morphine was given in large and regularly repeated doses without regard to danger of addiction that the individual improved sufficiently to permit definitive surgery. Following this he made steady progress.

This seemed to be the type of case from which we can draw the following conclusions: Some patients who develop a post-traumatic psychosis were really potentially psychotic before and this psychosis becomes apparent when the mental controls are relaxed by shock, pain, drug intoxication or all combined. Heavy doses of morphine will often give sufficient sedation, analgesia and euphoria to permit the mental controls to stabilize the individual partially again.



# PHYSIOLOGIC PRINCIPLES UNDERLYING THE TREATMENT OF INJURIES TO THE CHEST\*

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THE principal function of the cardio-respiratory system is to supply oxygen to the tissues and to remove carbon dioxide. All therapeutic endeavors in the management of chest trauma are, therefore, directed at the maintenance of this fundamental process. The management and complications of rib fractures, treatment of penetrating and perforating chest wounds and injury of the mediastinum and traumatic hernia of the diaphragm will be discussed. For convenience and completeness it is necessary to segregate the various phases of trauma under somewhat narrow headings. It is important, however, to recall that trauma does not respect anatomic barriers nor does the specialist philosophy confined to one body cavity or region apply to the proper management of injuries in any part of the body. The surgeon who supervises the therapy of trauma must think as a general surgeon. The definite pattern of progression common in some diseases does not apply in traumatic lesions. There are no guiding rules except an understanding of anatomy and perhaps more important, a physiologic approach to all injuries.

*The Chest Wall.* The normal mechanics of respiration result from the action of the muscles of inspiration. When one unit of muscle ceases to function, the other muscles are usually able to compensate and this response furnishes a factor of safety. For example, even if the outward and upward movement of the thoracic cage is prevented by plaster jacket or adhesive strapping, the diaphragm may carry on the respiratory exchange which will be adequate by increasing the amplitude of this excursion. If the more efficient but dangerous type of chest strapping encircling the entire lower costal margin is employed, restriction of the descent of the diaphragm will follow. In the patient with a dangerously reduced vital capacity this type of immobilization will not be tolerated; moreover, there is considerable difference in individuals and particularly between sexes in the amount of thoracic and diaphrag-

matic breathing. It follows, therefore, that if chest strapping is to be employed at all it will sometimes be on a trial and error basis and if it is not tolerated, should be abandoned.

Table 1 demonstrates the difference in two normal, healthy males in their tolerance to

TABLE 1  
INFLUENCE OF CHEST STRAPPING ON BREATHING

Cases	Unstrapped		One Strap Encircling Chest		Right Side of Chest Strapped	
	Vital* Ca-pacity	Maxi-mum Breath-ing†	Vital Ca-pacity	Maxi-mum Breath-ing	Vital Ca-pacity	Maxi-mum Breath-ing
Male 195 pounds	5,400	168	4,100	136	4,600	148
Male 200 pounds	5,300	111	4,400	127.5	4,350	117

\* Vital capacity in cubic centimeters.  
† Maximum breathing in liters per minute.

immobilization of the chest by an encircling strapping at the costal margin and by the often used half strapping at the level of any given rib.

Unless tremendous destruction of the chest wall has occurred, the effect of this *per se* on oxygen supply is probably in direct proportion to the associated pain which will cause splinting of the thorax and a decrease in respiratory movements.

During the past war numerous excellent accounts became available on the advantages of regional nerve blocking for the control of pain of the chest wall. Even minor contusions of the chest wall may be reflected in the underlying lung by localized atelectasis or hemorrhage; it becomes apparent, therefore, that the best prevention against these complications is relief of pain which in turn will prevent the splinting of the chest wall. The studies of Harmon, Baker and Kornegay<sup>1</sup> have revealed a significant increase in vital capacity following procaine infiltration into fracture sites. The same beneficial effects can be anticipated when paravertebral blocks are employed.

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**Hemorrhage.** Injuries to the chest may result in hemorrhage from either the systemic vessels or the pulmonary circulatory system. The intercostals and the internal mammary arteries of the chest wall are the most frequent offenders in that locality. A tear in the pulmonary parenchyma may result in blood loss from either a pulmonary artery or pulmonary vein. In the pulmonary system the pressures vary from 20 to 30 mm. of mercury and although hemorrhage from these vessels may be rapidly fatal, bleeding usually ceases because the elastic vessel walls contract into lung tissue. Fatal bleeding is usually avoided except in large, extensive wounds. The subjects of hemorrhage from the chest wall, lungs and complicating hemothorax have been extensively discussed in the literature. It is important, however, to emphasize that the treatment of severe hemorrhage from any part of the body may have a direct and sometimes devastating effect upon pulmonary function by the development of pulmonary edema.

It is probable that the physiologic changes in shock and in acute hemorrhage are similar, particularly as manifested in the lungs. These conditions are characterized by a rapid fall in blood pressure, slowing of circulation, loss of blood volume, anoxia followed by capillary endothelial permeability and tissue edema which finally reflects itself upon the heart and results in death. Experiences during the past war, which have been reported by Beecher<sup>2</sup> and others, have established with certainty the dangers of overloading the circulatory system with blood or plasma in a shocked patient. The same principles apply in cases of acute, severe hemorrhage. Eaton's investigations concerning pulmonary edema have verified these impressions.<sup>3</sup> He reports a predictable pattern of pulmonary moisture within a four-hour period following hemorrhage. He also reports that pulmonary edema may be aggravated by the intravenous use of physiologic sodium chloride, whole blood or plasma and that the effect is twice as severe when sodium chloride alone is administered in the presence of pulmonary moisture. In the experimental animals studied by Eaton, histopathologic lung changes of edema, hemorrhage and congestion were evident as soon as ten to twenty minutes after acute blood loss and were shown to persist for several days.

The lessons learned from war time experience

and experimental work along the same lines may not apply to the average injured patient but become of tremendous importance in the poor risk patient, the elderly or in the horribly injured subject. It should not be inferred that the value of transfusions of blood is questioned but it is important that reasonable quantities of blood be given as slowly as possible to these patients and that additional fluid requirements be made up by the subcutaneous route if possible.

**Shock.** There is no necessity for reviewing the accepted methods of combating shock which apply to all regions of the body. It is, however, important to emphasize that one feature peculiar to thoracic wounds, namely, partial suffocation, may be a factor in producing shock when the lungs are damaged. This may be the result of accumulations of blood or mucus in the trachea or bronchi or may follow hemorrhage or edema in the pulmonary parenchyma. One or both of these factors combined with the anoxemia of shock may be fatal. If respiratory exchange is embarrassed by the accumulation of bronchial secretions or blood clots, successful aspiration through the bronchoscope or by catheter suction may be life-saving. A pulmonary parenchyma drowned with blood or edema fluid constitutes a much more serious problem; oxygen therapy properly applied is probably the most satisfactory form of treatment. It is extremely important, therefore, to consider the possibility of partial suffocation before evaluating a patient's condition and particularly before attempting any major surgical procedure.

During the past war Samson, Burford, Brewer<sup>4</sup> and others described the entity of traumatic wet lung. This condition may be entirely the result of inability to cough up bronchial secretions because of pain and weakness. It has been postulated that reflex bronchial spasm may be involved. The practical applications remain the same; the bronchi must be cleared of secretions and the pain originating chiefly in the chest wall relieved. Final evaluation of the patient's condition must be delayed until these measures have been applied.

**Wounds of the Lungs.** Either penetrating or non-penetrating wounds of the chest may result in the formation of hemothorax, pneumothorax or both. In this connection it is important to emphasize that early and complete re-expansion of the lung with conservation of

cardiopulmonary function is of prime importance. This principle was successfully applied to thousands of injured men during the war and is equally important in civilian practice.

Air escaping from an injured lung may produce mediastinal and cardiac tamponade. If there is an associated tension pneumothorax, relief of the pneumothorax will usually be sufficient. Advanced subcutaneous emphysema may invade the mediastinum unless it is a rapidly accumulating one resulting from the rupture of a large bronchus. Ordinary instances of subcutaneous emphysema with some mediastinal invasion are usually not serious in nature.

*Intrathoracic Pressures.* The importance of the maintenance of negative intrapleural pressure in the mechanics of respiration is so well known that no discussion on this point will be included. The absolute necessity for prompt closure of sucking wounds has been understood for many years. It is true, of course, that the larger the opening the more dangerous the consequences but it is also important to remember that immediate reflexion will depend upon the vital capacity of the wounded man. For example, a small opening in the chest wall may be fatal to a patient whose vital capacity has been materially reduced by hemorrhage into the lung or pleura or for some other reason. The principle of the immediate closure of a defect of the chest wall has been substantiated for many years.

Diminished cardiac output and ineffectual oxygenation of the blood will become apparent with any marked intrathoracic pressure change. Bleeding into the pericardium resulting from either contusion or lacerating wounds may produce cardiac tamponade manifested by falling of systemic pressures, diminished pulse pressure and rising venous pressure. As these signs develop, the heart sounds become less audible until finally the phase of the silent heart is reached.

Failure to make the diagnosis of cardiac tamponade often is the result of too much dependence on roentgen examination. The presence or absence of motion in the cardiac silhouette is not recorded on a conventional x-ray film. Only examinations with the fluoro-

scope or roentgen kymography will establish the excursions of the heart. If one waits until a huge cardiac shadow is apparent, suggesting a collection of fluid, the results may be disastrous.

It is important to remember, however, that pressure relations within the thorax not only effect respiration but effect circulation which in turn will reduce the efficiency of oxygenation of blood. Mediastinal flutter may be associated with an open pneumothorax and all the mediastinal structures may be displaced. Not only the respiratory system but the circulatory system will be effected by torsion of the great vessels, particularly in the right chest by kinking of the vena cava.

The case of a victim of severe thoracic injuries is difficult to evaluate for reasons already described and others. The appearance of a man approaching death may dramatically change to an entirely satisfactory situation following intercostal nerve block and cleaning out of the airways with catheter or bronchoscopic aspirations. Conversely, a false sense of security may be shattered by the development of pulmonary edema, anoxia and death. A completely reliable evaluation of the oxygen saturation of the blood by clinical examination is impossible. Present laboratory methods are somewhat cumbersome but easier procedures for the determination of these data are the subject of considerable attention and certainly will develop.

To insure the greatest safety one must consider the possibility of visceral damage in all cases of thoracic trauma. Each lesion must be evaluated in terms of its effect on oxygen exchange.

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# AN ANALYSIS OF THE MANAGEMENT AND COMPLICATIONS OF MULTIPLE (THREE OR MORE) RIB FRACTURES\*

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**F**RACTURE of the rib represents one of the commonest of fractures. It is frequently dismissed as being relatively unimportant; it is overlooked or disregarded when associated injuries are present. As this report will show, fractured ribs are responsible for a formidable list of complications which often occur. Knoepp<sup>1</sup> showed a mortality of 5.9 per cent in patients with multiple fractures and a complication rate of 13 per cent for all rib fractures, single or multiple. Mortality rates as high as 10.4 per cent have been reported.<sup>2</sup>

We have analyzed a series of 109 cases of multiple rib fracture. These are consecutive cases treated by both the orthopedic and the general surgical services. The fracture of a single rib may result in any of the complications which are common in severe chest injuries, and we do not wish to have our exclusion of cases with only one or two rib fractures construed otherwise. But multiple injuries are getting to be the rule and our purpose is better served by considering multiple rib fractures alone.

This information was gathered from a review of the clinical records and x-rays; and when positive statements have been possible, we have made them. Roentgenograms are not the last word in the diagnosis of rib fractures. (Fig. 1.) Many fractures are not easily demonstrated. Also one can seldom afford to rely on one x-ray either for detection of intrathoracic complications or to follow their progress. (Fig. 2.) Physical examination is important but x-rays are essential to intelligent management of chest trauma.

In Table 1 the ages of patients by decades are tabulated. Most cases occur between the fourth and seventh decades inclusive. In the aged the injury is often trivial in nature. The age distribution is explained almost entirely on the brittleness which the ribs achieve since the

rib cage must be subject to frequent trauma at any age. Alcohol is an important contributory factor.

Eighty of 109 patients were male. Auto accidents were responsible for injury to sixty-five persons and two-thirds of these were passengers. (Table 11.) Falls accounted for twenty-eight others, fights for four more and three pedestrians were struck by street cars. In a few cases the etiology was unknown. All were admitted to the hospital for an average stay of ten days.

In Figure 3 we have arranged the location and number of ribs fractured. Our patients averaged 5.38 fractured ribs. Fracture of the left ribs is more common and at first we were not inclined to view this as significant; but when a study of stab wounds of the chest revealed the same tendency, we concluded that in some manner most individuals are able to offer more protection to their right side.

The twelfth rib is least likely to be fractured. This is followed by the first, eleventh and then second. The fourth through the tenth are quite exposed and are very frequently injured. This corresponds roughly to the findings of Knoepp,<sup>1</sup> and McCally and Kelly.<sup>3</sup>

The simultaneous occurrence of fracture of the first rib and clavicle on the same side is suggestive of common force applied through the sternum. (Fig. 4.) Approximately one-half of the fractured first ribs were associated with a fractured clavicle on the same side. Horner's syndrome has been noted by others<sup>4,5</sup> but we have no record of its occurrence in these cases. Fractures of the first rib following unusual muscular stresses,<sup>6-8</sup> blow on the sternum,<sup>9</sup> carrying bags over the shoulder<sup>10</sup> and the result of blast,<sup>11</sup> have been reported. It has been considered the rarest of fractures<sup>12</sup> but must take second place to the twelfth rib when multiple ribs are fractured.

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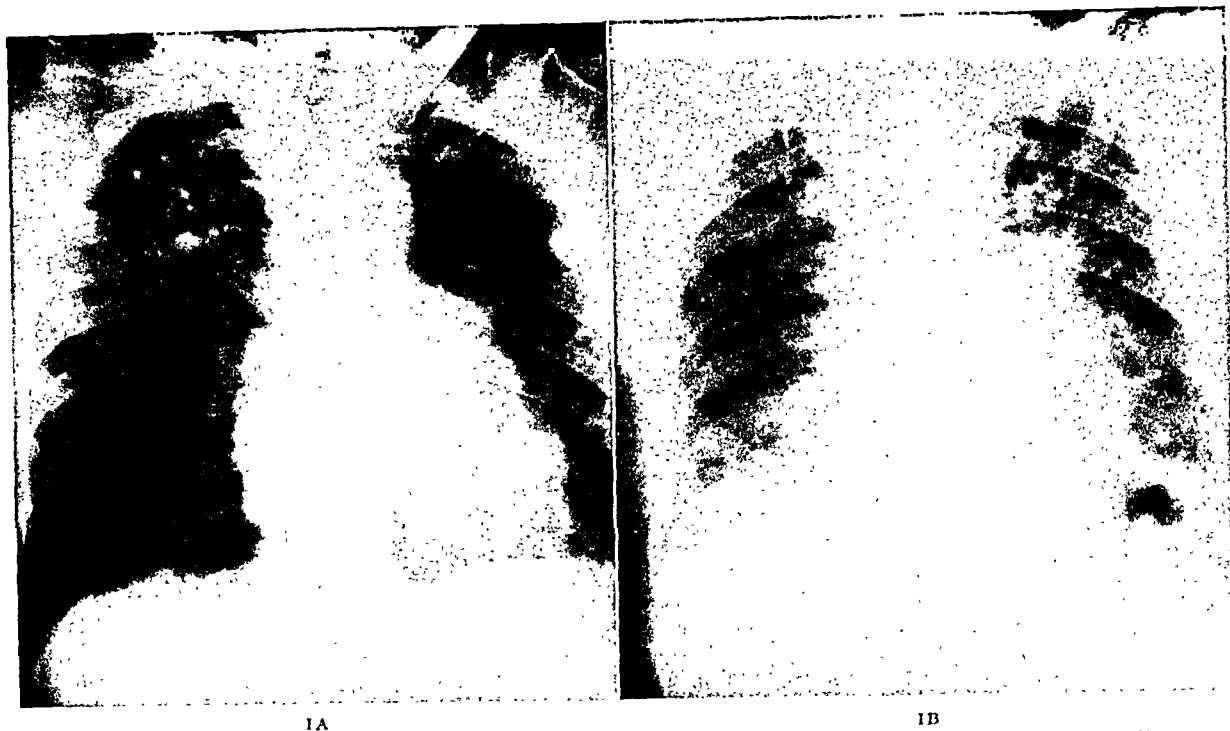


FIG. 1. Two views of fracture of first rib with fracture obscured by superimposed clavicle and second rib in one x-ray. Fracture of ribs is sometimes difficult to diagnose by x-ray.

*Associated Injuries.* A tabulation of associated injuries to these patients is interesting. (Table III.) It serves to emphasize three points: (1) the severity of injuries suffered by this group of patients, (2) the magnitude of traumatic forces in modern life and (3) the general nature of trauma.

TABLE I DISTRIBUTION BY AGE	
Age by Decade	No. of Cases
0-9	1
10-19	1
20-29	6
30-39	22
40-49	26
50-59	20
60-69	19
70-79	12
Average age.....	49
Males.....	80
Females.....	29

TABLE II  
HOW INJURY WAS INCURRED

	No. of Cases
Auto accident ( $\frac{2}{3}$ were passengers) ..	65
Falls at home or work.....	28
Fights.....	4
Hit by street car.....	3

A total of sixty-five patients suffered some injury other than fractured ribs. Included are sixty-one simple fractures of the extremities,

spine and pelvis in thirty-six patients, nine compound fractures in eight patients, ten instances of head injury, a few intra-abdominal and kidney injuries, a case of ruptured diaphragm and the inevitable disfiguring lacerations and contusions. All of these injuries were sustained within city limits where the speeds do not compare to those attained on the open highway.

TABLE III  
ASSOCIATED INJURIES

	No. of Cases
Simple fractures (in 36 patients).....	61
Head injuries.....	10
Compound fractures (in 8 patients) ..	9
Intra-abdominal injury.....	3
Kidney injury.....	2
Ruptured diaphragm.....	1

Trauma as a general surgical problem is amply demonstrated. Considerable experience and judgment is required of the surgeon who treats trauma and the obvious is a trap for the unwary. The general surgeon must sometimes consult the surgeon in special fields.

Rupture of the diaphragm is worthy of some comment. It is a relatively uncommon injury which is easily overlooked. The diagnosis, though not difficult, is usually delayed. Barium studies easily disclose a hernia which is almost always on the left. We have recently had occasion to make the diagnosis and carry out



FIG. 2. A and B, serial x-rays of case of multiple fractures of ribs showing progression of a pneumothorax and development of effusion; it would be impossible to detect changes of this nature without x-ray examination.

successful repair. According to a personal communication from the medical examiner, ruptured diaphragm is frequently seen in cases of sudden death but seems rare in those who survive the initial shock of trauma.

will do more harm than good by restriction of respiratory movement. We have abandoned all forms of strapping and our therapy now consists of reduction of pain by intercostal blocks, observation for complications in hope of preventing their full development and supportive therapy.

However, paradoxical respiration due to flail chest demands rib immobilization. (Fig. 5.) Milder instances may not require fixation but severe forms constitute a threat to life. A number of devices<sup>13</sup> have been utilized to lessen paradoxical excursions. We use a single-pointed cervical tenaculum. This instrument has proven most satisfactory in the common type in which the sternum is the mobile fragment. The instrument can be easily introduced into intercostal spaces and a good grip on the sternum obtained. One or more instruments are introduced and with 5 pounds of traction the excursions are materially lessened. We claim no originality for this method. Doubtless others have devices equal to this in every way. We have encountered one case of chondritis.

More will be said later about intercostal block but we use this as frequently as necessary to relieve pain. It affords more comfort to the patient when properly performed than any combination of drugs, and often one block will suffice. We avoid drugs which will depress cough

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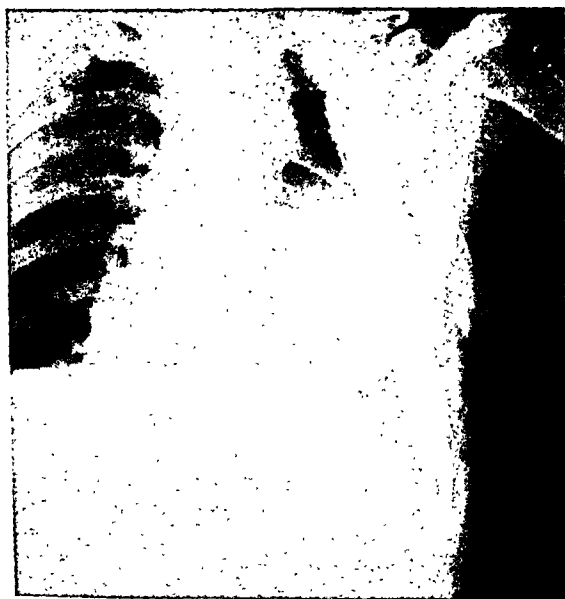


FIG. 2. C, same case as Figure 2A and 2B.

#### MANAGEMENT OF THE FRACTURES THEMSELVES

Immobilization of rib fractures is not feasible. Any method which achieves immobilization

for coughing must be encouraged. Expectorants, steam inhalations and nasal oxygen are useful.

#### COMPLICATIONS AND SEQUELAE

Only thirty-nine cases, or 35 per cent of this series, escaped without some complication marring their progress. (Table iv.) These patients

TABLE IV  
CHIEF COMPLICATIONS OF MULTIPLE RIB FRACTURE

	No. of Cases
Wet lung.....	39
Hemothorax and pleural fluid.....	25
Emphysema.....	28
Pneumothorax.....	14
Paradoxical respiration...	4 (3 deaths)
Ileus.....	18

comprise a somewhat "lightly" injured group as the average number of ribs fractured was only four, and there were only fifteen complicating injuries as compared to seventy-four complicating injuries in the remaining seventy cases. Any injury in which two-thirds of the sufferers will be subject to a complication is not to be taken lightly.

*Wet Lung.* This inclusive and descriptive term which many authors have employed<sup>14-17</sup> we have accepted to mean an abnormal accumulation of fluid in the lung. Some synonyms used are traumatic penumonitis, patchy atelectasis, bronchopneumonia, pulmonary congestion and infarction, but a distinction between these terms is impossible. De Takats<sup>18</sup> has experimentally produced it by chest wall trauma, pulmonary embolism and abdominal trauma and considers that wet lung is due to reflex motor and secretory stimulation of the bronchial tree. Thus intercostal block may not only relieve local pain but also break up a reflex arc. In chest injury such as we are considering, blood aspirated material, upper respiratory infections, cardiac failure and unconscious states are contributory factors.

Thirty-nine or 35 per cent of all our patients had wet lung. In this instance clinical evaluation is fully as important as roentgen findings. Clinically a "wet" respiration, ineffectual cough, rales, dyspnea and cyanosis are apt to put in their appearance singly or combined. Cough is shallow and poor in quality. Due to pain, respirations are rapid and shallow and there is often low-grade fever.

Bed rest has only slight effect on the incidence of wet lung. Thirty-two patients had associated injuries which enforced bed rest.

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The incidence of wet lung in this group was 40 per cent. In seventy-seven cases not confined to bed the incidence was 34 per cent. Visible damage to the underlying lung did increase the incidence. When hemothorax, pneumothorax or emphysema were present, we found that approximately one-half of these cases had

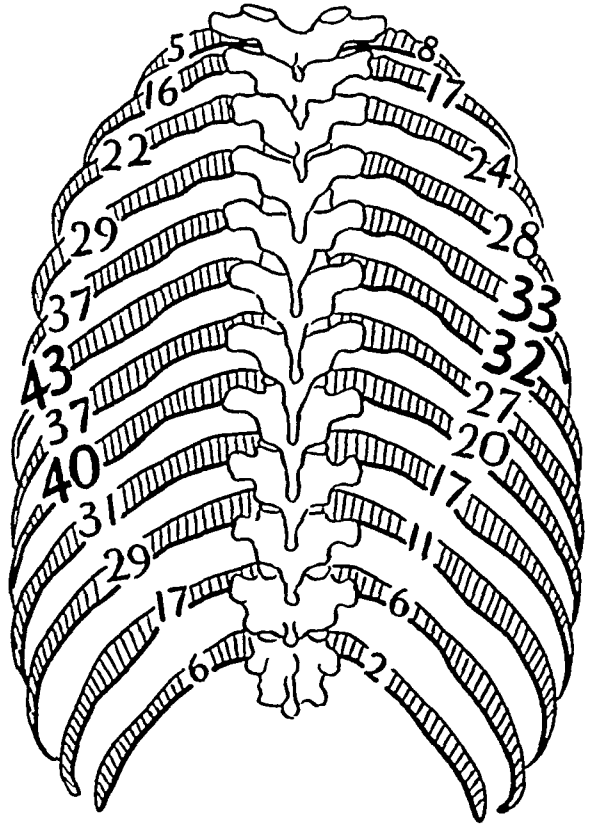


FIG. 3. Distribution of fractures as to rib; for our purpose we have believed that the exact location of the fracture was not significant.

"wet" lung, whereas only one-third of the remainder of the cases had this complication.

We regard "wet" lung as a complication which may have serious implications. It interferes with gaseous exchange as evidenced by cyanosis. We believe it is a predecessor to atelectasis and pneumonia and, in the elderly, it is a significant factor in circulatory failure.

Strapping devices and narcotics which were so widely accepted in the past<sup>19</sup> are out of place in the general treatment of rib fractures. We were interested to find a report of bilateral edema of the legs and ankles following strapping of the chest.<sup>20</sup> This disappeared within twenty-four to forty-eight hours after removal of the tape. This is an extreme case illustrating how great the insult to circulation may be. Strapping does not satisfactorily relieve pain.

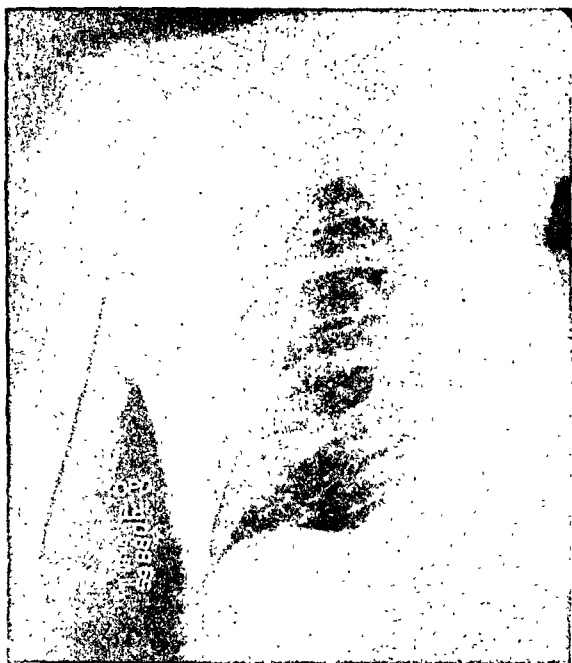


FIG. 4. In this series fractures of the clavicle were present in one-half of the cases of fracture of the first rib. This is probably due to force applied through the sternum.

The patient's chest should be unrestricted and by means of intercostal block which many have advocated<sup>14-17, 19-21</sup> he must be made comfortable enough so that he can move about and cough without pain. In this series, however, many were blocked initially and repeatedly and still developed wet lung. We are not sure that the condition can be wholly prevented by any means, but there seems little doubt that intercostal blocks are an important part of the treatment.

Wet lung must be actively and aggressively treated. The patient made comfortable by intercostal blocks must then cough. Patients may have to be cajoled, threatened or assisted, but persistence usually pays dividends. If productive cough cannot be obtained, tracheal aspiration or even bronchoscopy must be employed. Nasal oxygen and penicillin are frequently of value.

*Accumulation of Blood and Fluid in the Pleural Space.* Twenty-five cases, or 25 per cent of our patients, had blood or fluid in the pleural space. Twelve of these were graded as slight for the fluid only obscured the costophrenic angle. Three patients yielded 1 L. or more of bloody fluid on thoracentesis and were regarded as severe. The ten remaining cases were classified as moderate. The patients with

slight hemothorax required no treatment beyond observation. It has been our policy, when significant quantities of blood are present, to remove it as thoroughly as possible by thoracentesis or by water seal drainage. The latter method recommends itself particularly when pneumothorax is also present. In a discussion of hemothorax Melick and Spomer<sup>22</sup> cite many experiments, the oldest being performed on horses as early as 1829 by Trousseau and LeBlanc, to show that respiratory and cardiac movements defibrinate the blood and successive layers of fibrin are deposited on the pleural surfaces. Because of this loss of fibrinogen blood withdrawn from the pleural space will often stay liquid for a long time. In some cases the presence of blood incites exudation from the pleural surfaces and much that is interpreted as continued bleeding is simply increase in the fluid content due to weeping from pleural surfaces. This fluid if tested may have a hemoglobin content considerably below that of blood. The factors which influence successive layering of fibrin are unknown and we are unable to predict in which patients the blood will be absorbed and which will go on to organizing hemothorax. Infection may play a role as almost all patients going on to organization exhibit some fever. When confronted with organized hemothorax decortication remains the only practical recourse.<sup>23</sup> Loculation prevents effective thoracentesis and permanent crippling results if it is left undisturbed. (Fig. 6.)

No patient in this series required decortication. They all represent closed wounds except that small punctures of the lung were present in many of them and we encountered no instances of infection in the pleural space.

All three patients with severe cases were subjected to thoracentesis and in addition five with moderate accumulations were tapped or treated with an intercostal tube. Since we cannot predict the ultimate fate of blood in the pleural space, it is probably better to err slightly on the radical side and perform thoracentesis in borderline cases. (Fig. 7.) Fifteen of these patients also had pneumothorax and/or emphysema and nine patients presented evidence of wet lung.

*Emphysema and Pneumothorax.* Emphysema is much more common than pneumothorax. The former was present in twenty-eight cases (25.7 per cent) and the latter in fourteen cases (12.8 per cent). It is likely that

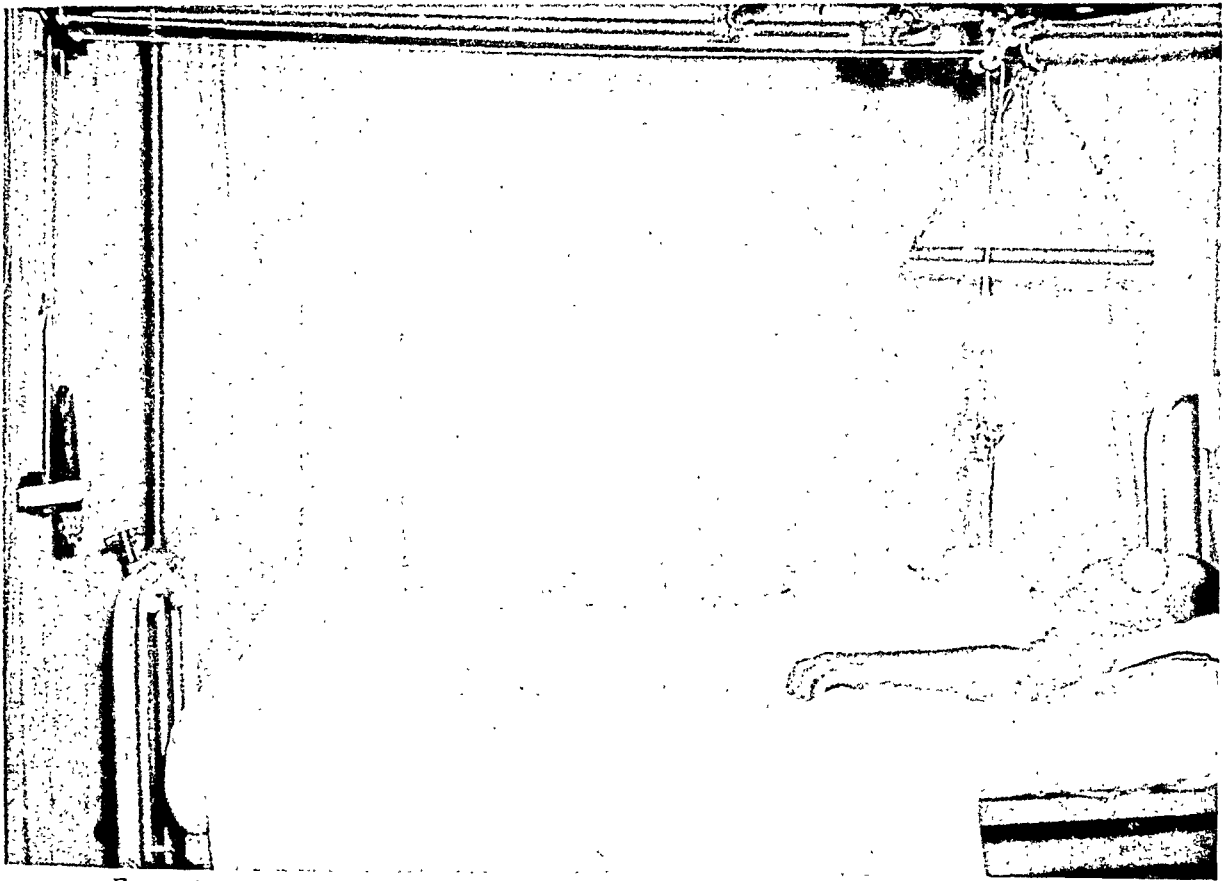


FIG. 5. A simple traction device to control the paradoxical excursions of the thoracic cage.

small amounts of air are unrecognized even in good roentgenograms.

Subcutaneous emphysema is evidence of puncture of the lung. It may occur with rupture of the trachea or esophagus. No cases of this latter type were encountered in this series. Presumably the offending agent is the jagged rib end and the visceral pleural tear must usually be sealed off quickly since so few of these cases are progressive or associated with pneumothorax. Pneumothorax was present in only nine cases.

Emphysema requires very little in the way of treatment even when severe. When associated with pneumothorax we frequently use water seal drainage. Occasionally emphysema is rapidly progressive and may become very extensive. We believe that a small thoracotomy tube will stop this rapid progression even when no "pneumo" is present by induction of a small pneumothorax which pulls the lung away from the rent in the parietal pleura and provides easy exit for air issuing from the damaged lung. We are at a loss to explain why even severe cases of emphysema may exist without

pneumothorax unless adhesions are present. Subcutaneous emphysema obscures much detail in x-rays and thus many cases of pneumothorax may be missed.

Pneumothorax requires watchful management. (Fig. 2.) In many instances air will be absorbed but frequently this takes much longer than one would expect. At the same time one must take certain risks in waiting for complete absorption.

In the treatment of pneumothorax we think it is a definite advantage to re-expand the lung and hold it out by means of a water seal drainage apparatus. The complete expansion must be maintained for three to four days. This is less time than would be expended in waiting for the air to absorb. We think it is a mistake to dismiss anyone from hospital observation while pneumothorax of any degree is still present. A little strenuous effort, a hard cough or sneeze or a hiccough may dislodge the material which has plugged the hole and the result may be tragic for the patient.

Some claim that pleural laceration will heal better when the lung is collapsed. We have not



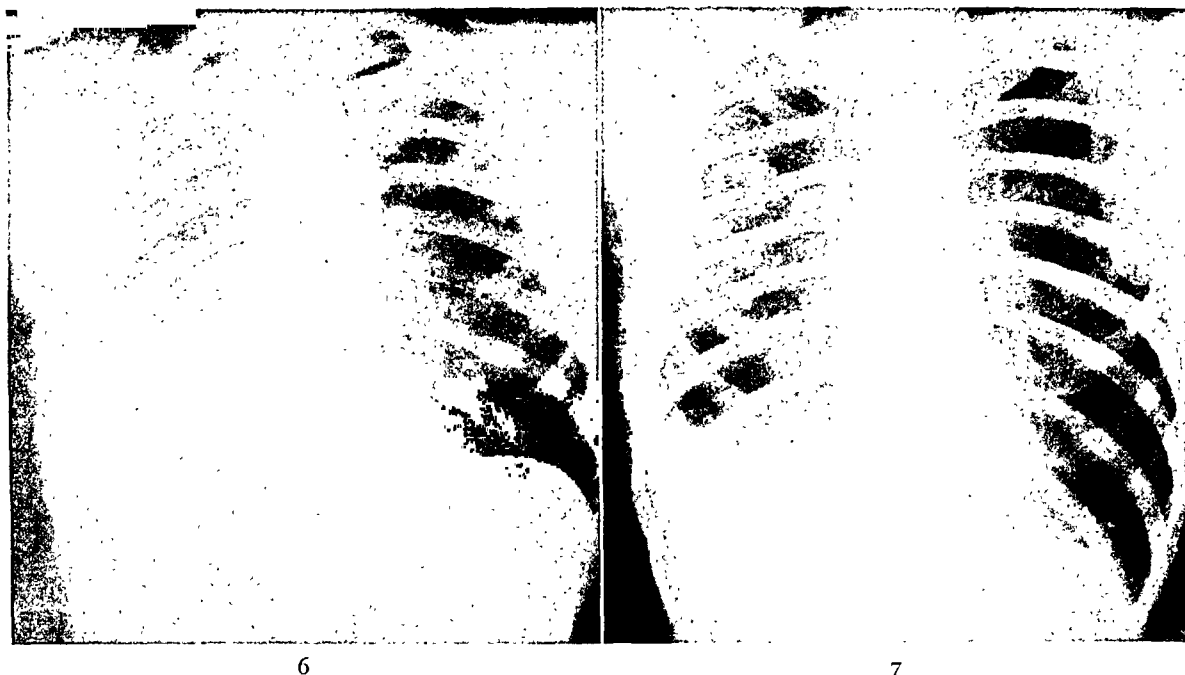


FIG. 6. This patient shows scoliosis to the affected side; a narrowing of the rib interspaces by x-ray. Following decortication these evidences of captive lung and fibrothorax disappeared.

FIG. 7. From the appearance of this x-ray one would consider this a moderate hemothorax. However, 1,000 cc. of blood were removed by thoracentesis.

observed any delay under our treatment. In fact, apposition to the parietal pleural surface may be advantageous for healing. At any rate, there is no tendency for the lung to recollapse after the water seal drainage has been removed if the lung has been fully expanded for three to four days.

Since all of these cases were closed pneumothoraces, the physiologic upset was not marked and there were no instances of tension pneumothorax. A ball valve lesion in the visceral pleura which allows air to enter the pleural space on inspiration only to be trapped on expiration must be treated at once with a water seal drainage system.

No serious sequelae due to pneumothorax have been encountered in this series. Four of these patients were intubated and six were tapped, and there was no pleural infection.

The only extrathoracic complication of importance is ileus. We have grouped gastric dilatation and intestinal ileus together. Eighteen cases (16.5 per cent) of significant ileus occurred in this series. This is considerably above the incidence reported by Altemeier and Wadsworth.<sup>24</sup> These authors report ten cases in 454 cases of fractured ribs. However, they excluded from consideration cases of pneumo-

thorax, fractured pelvis and fractured vertebrae. They considered ileus to be due to irritation of the splanchnics from direct injury by the fractured ribs or reflexly. The list of associated injuries in our series is fairly imposing. It includes one spine fracture, two skull fractures, eight fractured extremities, two fractured pelvises, two kidney injuries and two cases of heart failure. Furthermore, all but one case displayed wet lung or other intrathoracic injury and that case had a fracture of L 2. Thus it can be seen that all these patients were severely injured. Spine fractures, kidney injuries, pelvic fractures and heart failure are all apt to exhibit ileus. Retroperitoneal hemorrhage in the former three instances may play a part.

Whatever the cause, ileus may become extreme and be an appreciable hazard. We have seen great gastric dilatation within a few hours after injury. (Fig. 8.) In this instance a tremendously distended abdomen, grunting respirations, cyanosis and tachycardia were present to a marked degree. A gastric tube brought dramatic relief within a few minutes and it was possible to ascertain the true extent of the patient's injuries. For small bowel ileus we regularly employ a long tube. For large bowel ileus small repeated doses of pitressin are valu-

able. Ileus should never be neglected. To get the best results treatment must be active and direct. We do not believe that drugs have any effect except in instances of large bowel ileus.

#### DEATHS

Eleven, or 10 per cent of these patients died. (Table v.) Nine patients had severe associated

TABLE V  
DEATHS

11 Cases—10%
9 Cases with severe associated injuries
4 cases of primary chest death
Intrathoracic hemorrhage—2
Delayed intrathoracic hemorrhage—2

injuries. It was difficult to evaluate the role chest injury played in their deaths but, even when death was not due to chest injury, it was always decisively contributory.

In those patients in whom chest injury played a decisive rôle, delayed hemorrhage was responsible in three. As an example: M. W., a sixty year old colored female was struck by a car, suffering fractures of the left first to eighth ribs inclusive, the right second rib, the pelvis and the left clavicle. Despite many intercostal blocks she developed wet lung and was bronchoscoped. She developed rather marked emphysema and ran a low fever for three days. However, her condition was improving when she suddenly died on the fifth day. An autopsy at the coroner's office revealed intrapleural hemorrhage. No other explanation was offered for her sudden death.

The softening of fibrin clots, respiratory movements, infection and contusion to vascular walls with subsequent necrosis might all enter into such a termination.

We are sure that chest injury played an important contributory role in several other deaths. We are convinced that wet lung, especially, is an important factor particularly in the elderly patient whose circulation is not too robust and whose pulmonary reserve is low.

#### SUMMARY

1. One hundred nine cases are presented in which each patient had three or more fractured ribs.
2. The cases are predominantly males in the fourth and seventh decades.
3. There seems to be a definite tendency for fractures to be more frequent on the left.
4. Both the shortcomings of x-rays and the necessity of obtaining serial x-rays are stressed.

November, 1940



FIG. 8. Marked gastric dilatation following chest trauma; this picture was taken two hours after injury. A Levin tube passed into the stomach immediately and remarkably relieves these patients.

5. The coincidence of fractured first rib and clavicle on the same side is discussed.
6. These patients presented an imposing array of associated injuries which serves to emphasize that trauma is a general surgical problem and that a thorough, systematic examination is necessary. Ruptured diaphragm is discussed.
7. Our general program for treatment of fractured ribs is presented, emphasizing the importance of intercostal block and avoidance of restrictive dressings and cough depressants.
8. The fixation of the "stove in" chest is discussed.
9. Intrathoracic complications may be anticipated in two-thirds of all cases of multiple rib fracture.
10. The causes and treatment of wet lung are discussed at some length.
11. The incidence, treatment and sequelae of hemothorax, pneumothorax and emphysema are discussed. It is important to remove blood completely from the pleural space and to institute prompt measures for the re-expansion of collapsed lung.
12. This series had a 10 per cent mortality. Delayed hemorrhage is a definite hazard and wet lung is an important contributory cause.

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# TREATMENT OF PENETRATING AND PERFORATING CHEST WOUNDS\*

A DISCUSSION OF ITS COMPLICATION, THE ORGANIZED HEMOTHORAX

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THE penetrating or perforating chest wound is by its very nature a wound of violence. Nowhere but under the conditions of warfare can this type of wound be studied and treated in truly significant numbers. This lesion as it occurs in civilian life is closely related to its counterpart inflicted in armed combat. Therefore, the principles evolved from the observation and treatment of a large group of these wounds should be applicable to their management in civilian life.

The statistics herein presented and the suggested modes of treatment result from the experience<sup>1</sup> of a group of surgical teams operating in the European theater during the recent war.

Chest injury mortality has been reduced from approximately 25 per cent in World War I to about 6 per cent in the last conflict. This improvement results in great part from a better understanding of respiratory physiology and the application of this knowledge to actual treatment. Obviously, improved anesthetic technics and chemotherapeutic advances played an important role in these encouraging figures.

## PRINCIPLES OF TREATMENT

Much assistance in guiding treatment of the chest casualty can be gained by an accurate estimate of the course of the wounding missile. The amount of damage and the organs involved may be indicated by such knowledge. In the case of a retained missile anteroposterior and lateral x-rays of both chest and abdomen will enable the operator to plot the probable wound tract and to compute the organs involved. The value of two-position views (anteroposterior and lateral) cannot be overemphasized in the diagnostic process of accurate wound appraisal. The course of a perforating wound can be estimated by lining up the wound of entry with the wound of exit when proper allowance is made for position

of the wounded subject at the time of injury. By virtue of these studies involvement of the mediastinum or diaphragm may be indicated taking the case out of the simple chest wound category.

Contrary to the situation in the abdominal wound when importance is attached to the interval between injury and operation, the significant period in the chest wound is that required to stabilize cardiorespiratory function and relieve anoxia.

The establishment of an adequate airway is of prime importance in emergency treatment of the chest wound casualty. Normal respiratory exchange must be instituted both for the purpose of relieving anoxia and also for the proper preparation of the patient for operation if the latter is indicated. Anoxia, which may be the result of an obstructed airway, wet lung, depressed cough reflex due to pain, etc., may contribute measurably to the picture of shock which these patients frequently show. Diminished blood volume will contribute in varying degrees to the shock state in which many of these patients are found. However, in other patients with minimal blood loss although apparently in severe shock, marked improvement may be obtained by correcting the conditions causing anoxia.

The sucking chest wound indicates a connection between the pleural cavity and the external atmosphere. Early establishment of an intact thoracic cage is a basic necessity in restoring normal respiratory physiology. Emergency treatment can be accomplished by a simple occlusive dressing to be followed later by indicated surgical repair.

Hemoptysis is an indication of pulmonary parenchymal damage. It accompanies the majority of chest wounds. The presence of blood in the tracheobronchial tree contributes to the obstructive factors preventing normal

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aeration. Its early removal, either voluntarily by the patient's efforts or mechanically with the operator's assistance, is to be encouraged.

Oxygen administration as a supportive measure is a valuable adjunct in assisting the patient with a chest wound over periods of difficult aeration. It is not stressed purposely in this article in order to emphasize the more basic principles of re-establishment of normal pulmonary function.

In summary the surgeon will achieve the best results in a chest casualty by attempting to establish normal respiratory exchange with an unobstructed airway in a patient with fully expanded lungs and an intact thoracic wall. Blood replacement, but not overloading of the cardiovascular system, is indicated when there is assurance that the shock state is not entirely due to anoxia.

#### PRACTICAL APPLICATION OF THESE PRINCIPLES

*Evaluation of Damage Inflicted.* History, physical and roentgen examination will accord the examiner a means of estimating the amount of injury present in the chest wound casualty. Any suspicion of mediastinal or diaphragmatic involvement calls for additional investigation and therapy from this point onward. The presence of a retained foreign body at this point is of no concern unless it is of an unusual size or nature.

*Aspiration of the Chest.* The presence of blood and air in the penetrated chest cavity is a common finding in chest injury. Blood and air occupy space previously reserved for the functioning lung. The early and complete removal of blood and air is a prerequisite to re-establishment of a fully expanded, functioning lung. This can be accomplished by repeated and thorough thoracentesis. Considerable objection has been raised in the past to the re-expansion of the freshly wounded lung by aspiration of air or blood. It has been stated that re-expansion of the wounded lung will incite fresh bleeding or that pneumothorax is valuable in preventing continued hemorrhage. We have not found this to be so. It was the common experience of many members of this group to examine many extensively lacerated lungs in the course of operative procedures from two to twenty-four hours after initial injury. It was unusual to observe hemorrhage or oozing of note in this lacerated tissue. Major hemorrhage that continued or was re-initiated arose

from systemic vessels such as the internal mammaries or the intercostals and required active intervention for control. It was also our impression that patients with injuries to the major pulmonary vessels rarely if ever survived long enough to reach centers for definitive treatment.

In addition to regained pulmonary function the re-expanded lung tends to prevent the establishment of a massive pleural infection should contamination be overwhelming. Thus if infection should complicate the situation, the surgeon would be faced most probably with a small basal empyema; whereas if expansion were incomplete, he would have to deal with a total empyema.

Failure to establish complete re-expansion by repeated and thorough thoracentesis also carries the threat of a chronically collapsed and imprisoned lung. This condition condemns the patient to impaired respiratory reserve and the prospect of a second major pulmonary operation.

*Intercostal Nerve Block.* This is a frequently described<sup>2-4</sup> and simply performed procedure which is of paramount importance in treating the chest wound patient and also in preparing him for indicated operations. Severe chest pain is a frequent complaint of patients suffering penetrating or perforating wounds of the chest. This pain is contributory not only to the shock state but also tends to suppress the voluntary cough reflex on which the patient relies to rid his tracheobronchial tree of impeding substances. Relief of chest pain by intercostal block is an important factor in breaking up the cycle described as wet lung.<sup>5</sup> This procedure is more efficient in the relief of chest pain than the administration of morphine which must be given with restraint in chest injuries. For intercostal block to be most effective it must be performed at least two levels above and below the area of injury. There is no contraindication to repeating intercostal blocks should it be required for control of pain.

*Tracheobronchial Aspiration.* A large amount of the products of injury to the lung parenchyma find their way into the tracheobronchial tree. All tend to accumulate in the tracheobronchial tree of an injured lung. The condition is cumulative and with the patient's inability to eject these substances, voluntarily normal air exchange is blocked. This condition can be corrected in two ways. A suction

catheter can be introduced into the trachea in a manner previously described.<sup>6,7</sup> The apparatus required is simple and usually available. The presence of a catheter between the vocal cords and in the area of carina is of itself sufficiently stimulating to initiate a cough reflex. Suction

TABLE I  
COMPARATIVE REPLACEMENT THERAPY  
(ABDOMINAL VS. THORACIC WOUNDS)

Cases	Average Amount of Blood Per Case	Average Amount of Plasma Per Case
907 Abdominal wounds.....	2,382 cc.	888 cc.
1,119 Thoracic wounds.....	1,160 cc.	640 cc.

will remove much of the obstructing debris and help to re-establish normally functioning lung tissue. This procedure may be repeated at frequent intervals with beneficial effect. In the hands of a trained operator bronchoscopy will accomplish the same effect to a greater degree. The secondary dilating effect of bronchoscopy on the tracheobronchial tree is of further assistance in correcting this condition. Bronchoscopy may also be repeated as required.

**Fluid Replacement.** Unless major blood loss is immediately obvious, a much better evaluation of blood replacement in a thoracic casualty can be made after cardiorespiratory balance has been attained by the emergency measures already outlined. Overloading of the circulatory system is easily accomplished in the chest case by overzealous blood or fluid replacement. The traumatized lung, which is frequently compressed by an accompanying hemopneumothorax, is a crippled organ which will respond poorly to an increased work load. Table I shows comparative replacement figures in thoracic and abdominal casualties.

The rate of replacement is equally important and should never be rapid except in cases of obvious major blood loss or continued blood loss. Plasma and other fluids play a less important role in replacement therapy and probably should be reserved for later use in the correction of a contorted blood picture. It may be predicted that the problem of fluid replacement will require more careful judgment in administration for civilian casualties since the fre-

quency of cardiac and pulmonary complications will be higher in that group.

**Indications for Thoracotomy.** While the average penetrating or perforating wound of the chest can be handled by conservative surgical measures, there are certain indications

TABLE II  
OPERATIVE PROCEDURES

	Cases	Mortality Rate, Per cent
Chest wall only.....	768	6.9
Thoracotomies.....	435	12.4

RECORDED INDICATIONS FOR THORACOTOMY

Traumatic.....	156
? of thoraco-abdominal wound.....	122
? of persistent bleeding.....	36
Injury to mediastinum.....	20
Foreign body.....	11
Lung laceration.....	3
Bone fragments.....	3
Bronchial fistula.....	3
? of esophageal wound.....	3

for thoracotomy. These indications are definite and limited. Table II records the number of thoracotomies performed in a group of about 1,200 chest casualties. The indications warranting thoracotomy are listed.

The greatest number of cases is listed under the heading, "Traumatic Thoracotomy." In these instances the operative procedure was actually forced on the surgeon by virtue of the size of the wound. Here the size of the wound will permit evaluation of parenchymal damage, thorough policing of the pleural cavity and removal of easily accessible foreign bodies in little more time than is required to reconstruct the chest wall and establish an intact pleural space. The traumatic thoracotomy will not be seen commonly in civilian life since the majority of these casualties were the result of wounding by high explosive shell fragments. If injury to mediastinal structures or perforation of the diaphragm cannot be diagnosed by ordinary measures, thoracotomy is mandatory. An untreated perforation of the esophagus or stomach will certainly increase the morbidity if not the mortality of these casualties.

Continued bleeding from systemic vessels required further and careful investigation. Among the most common sources of continued



FIG. 1. Typical x-ray of organized hemothorax following penetrating wound of chest; shell fragment at base of right pleural cavity. Note compressed and imprisoned right lung; narrowed intercostal spaces and flattened chest cage on right.

hemorrhage were injured intercostal and internal mammary vessels.

Foreign bodies, lung lacerations or bone fragments are not in themselves indications for thoracotomy in the primary definitive treatment of the chest casualty. Foreign bodies, unless of unusual size or composition, may be removed at a later date under more auspicious circumstances. Laceration of the lung is an inevitable complication of almost every penetrating or perforating chest wound. This lesion alone does not call for operative interference. The ability of damaged lung parenchyma to repair itself without complication was frequently noted by observers in this group.

Typically, small peripheral bronchial fistulas will manifest a tendency to spontaneous closure providing that a re-expanded lung can be kept in close contact with the chest wall. Larger defects in the major bronchial branches will require operative repair.

*Pressure Pneumothorax and Subcutaneous Emphysema.* Pressure pneumothorax occurred in surprisingly few instances in this collection of cases. When present it is a serious threat to respiratory stability and requires immediate correction. This condition results from a ball-valve type of action in the chest wall or in a

traumatized bronchus. With each successive phase of inspiration there is an increase in intrapleural pressure. Eventually severe mediastinal shift occurs with marked respiratory and circulatory embarrassment.

This serious complication may be diagnosed rapidly and simply by physical signs, the most

TABLE III\*  
Anesthetic Agents

	Cases
Ether.....	307
Pentothal.....	108
Gas-oxy-ether.....	673
Novocain.....	121

Type of Inhalation

Endotracheal.....	862
Open.....	56
Mask.....	33

\*Tables I, II and III, slightly modified, have been taken from "Forward Surgery of the Severely Wounded."<sup>1</sup>

prominent being the easily palpable tracheal shift away from the wounded side.

The immediate danger can be forestalled by relieving built-up pressure in the affected chest through the use of a needle connected to a water-seal trap. This was accomplished often in the field by inserting an intravenous-type needle in the second interspace and connecting the needle to a container of water below the patient's body level by plasma tubing. This simple plan is effective until the underlying defect can be corrected.

Subcutaneous emphysema is seen quite commonly in chest wounds. Its most frequent source is the punctured pleural surface. Of more serious import is the emphysema resulting from esophageal perforation and tracheal or major bronchial injury.

These subcutaneous extravasations of air subside rapidly after the underlying pathologic disorder is repaired and carry no special significance other than diagnostic.

*Anesthesia.* The most common type of anesthesia used was gas-oxygen-ether administered by the endotracheal route as outlined in Table III. Contemplated or probable invasion of the pleural cavity during an operative procedure demands pressure-controlled anesthesia administered by a competent anesthetist. The use of pentothal or local anesthetics should be entirely reserved for those cases in which there will be no question of entering the pleural cavity.

#### THE ORGANIZED HEMOTHORAX

Among the postoperative problems to be dealt with in the chest casualty is the com-

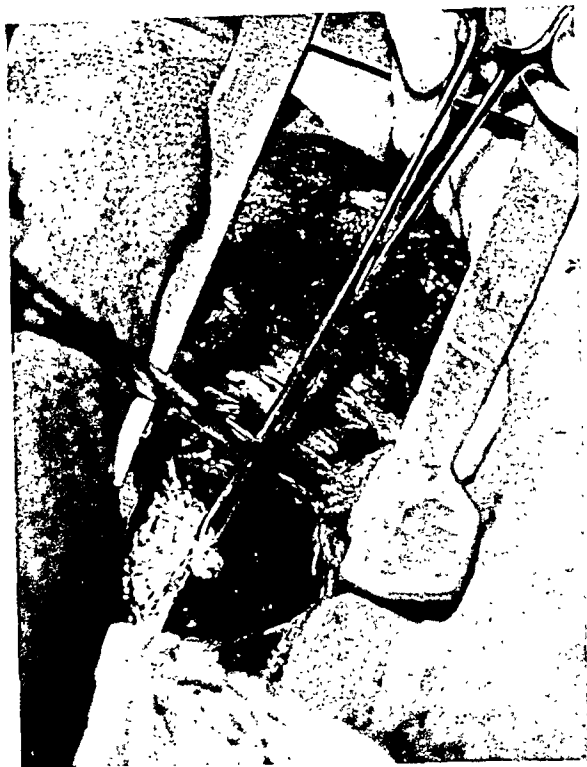


FIG. 2. Thoracotomy for decortication; fibrous encapsulating membrane of partially decorticated lung held in Allis clamps; underlying normal, shiny pleural surface of lung below crossed clamps.



FIG. 3. Gross specimen of excised fibrous peel removed from visceral pleural surface.

plication of organized hemothorax. The lesion is characterized by an immobile, unexpanded lung which is held captive by a thick, connective tissue membrane extending over all available visceral and parietal pleural surfaces. Usually varying amounts of old blood products are present as well as an unorganized clot and a shaggy detritus which is the result of reactive exudation and old hemorrhage. A typical x-ray of this condition is shown in Figure 1. The exudate may be infected or it may be sterile.

The obvious treatment of this complication is the prevention of its occurrence by the application of the principles already outlined for management of the original chest wound. Unfortunately, under conditions of warfare the continued active treatment of the original chest casualty was prohibited in many cases by unusual circumstances. Under civilian conditions there should be little difficulty in maintaining a completely expanded lung and a thoroughly policed pleural cavity. It is conceivable that small residual empyemas would not be unknown under these conditions but the occurrence of organized hemothorax should not be a major problem.

The establishment of an organized hemothorax of major degree leaves the patient with diminished pulmonary parenchymal function. In addition gradual immobilization of the chest wall on the affected side increased respiratory disability.

Decortication, the operation by which the encapsulating membrane or peel is removed from the pleural surface of the lung to permit its reexpansion, is not a new procedure.<sup>8,9</sup> It has been utilized most frequently since the end of the last century in assisting the obliteration of old, chronic empyema cavities. It has been re-employed during and since the late war by many operators<sup>10-13</sup> for the correction of this lesion and related conditions.

Actually there is some question concerning the functional value of decorticated lung following varying periods of imprisonment. Investigation of this problem is now in progress.

The operation of decortication is performed most profitably three to six weeks following the original injury. It is during this period that the investing membrane is sufficiently organized to allow easy peeling but at the same time is not too adherent to cause injury to the underlying lung during the process of removal. The most important areas requiring careful removal of the imprisoning membrane are the peripheries of the imprisoned lung when it is contiguous with the chest wall, the fissures and



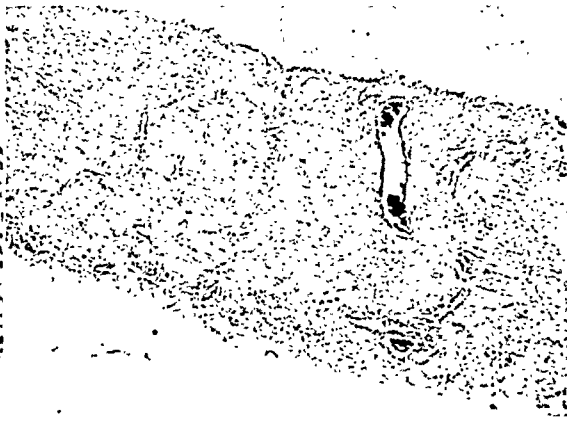


FIG. 4. High power microscopic cross-section of fibrous peel; upper right field shows early phase of organization with old blood, fibrin and cell detritus. In the periphery of this area there is fibroblastic invasion; remainder of field is occupied by organized fibrous connective tissue. ( $\times 100$ .)

FIG. 5. Low power microscopic cross-section of the fibrous peel showing well developed blood vessels running generally at right angles to the connective tissue stroma; lower portion of field shows early organization and is apposed to the visceral pleural surface. Upper portion of field is adult connective tissue and lines the pleural space. ( $\times 8$ .)

the diaphragmatic surfaces. Small central areas of this investing membrane may be found to be so intimately attached to the pleural surface that they defy safe removal. Areas of this type



FIG. 6. Postoperative x-ray of decorticated right lung. (Figure 1 is preoperative x-ray.) Tube in ninth right interspace to drain small residual empyema; right lung reexpanded and shell fragment removed.

when not removed have not impeded full re-expansion of the lung.

Removal of this membrane or peel leaves

behind it a normal-appearing, shiny and expansible pleural surface. (Fig. 2.)

The membrane is composed of fibrous connective tissue (Fig. 3) which results from reaction of the pleura to the retained blood products. Organization of these products takes place with vascularity being supplied by the underlying pleura. High and low power microscopic sections typical of this membrane are shown in Figures 4 and 5.

The presence of infection hastens the process of organization of this membrane. Infection does not contraindicate the operation of decortication. Quite frequently a low grade infection is present but the procedure may be carried out with little fear of serious complication, particularly with the assistance of antibiotic protection. Small basal empyemas may occur but can be handled effectively by simple drainage. Figure 6 shows a typical patient postoperatively who had decortication, with drainage tube at the base.

Occasionally we have used the intercostal tube in the later postoperative period as an open form of drainage to complete evacuation of an obviously infected residual space.

It is interesting to note that the markedly thickened membrane or peel which is also present on the parietal surface of the pleural cavity does not require removal. The removal of this portion of the membrane is difficult to accomplish and unnecessary as shown by follow-up x-rays of these patients. With full

expansion of the lung and the return of normal respiratory exchange, the markedly thickened parietal membrane thins out and within a period of six to twelve months can scarcely be demonstrated in the chest film.

The institution of remedial breathing exercises early in the postoperative period of the decorticated patient is of extreme value in re-establishing normal thoracic function. The value of these exercises has been amply demonstrated by Edwards and Harken.<sup>14</sup> They serve not only to correct thoracic cage deformities but aid in re-expanding and maintaining re-expansion of the released lung.

#### SUMMARY

1. There has been a marked improvement in the treatment of the acute chest wound based on a better understanding of respiratory physiology.

2. Although the principles of treatment and their application are based on experience gained under conditions of warfare, it is believed that they can be applied profitably to the civilian casualty.

3. The importance of establishing stable respiratory function before operation is pointed out. The methods at hand for accomplishing this stabilization are described.

4. The implications of fluid replacement therapy in the chest casualty are discussed.

5. The indications for thoracotomy in wounds of the chest are presented.

6. The complication of organized hemothorax is discussed and its treatment described.

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# INJURIES TO THE MEDIASTINUM\*

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**M**EDIASTINAL structures may be injured by penetrating instruments or projectiles, non-penetrating crushing violence, or in the case of the trachea and esophagus by objects introduced through these passageways. The structures which are of traumatic surgical interest are the heart and great vessels in the anterior and superior mediastinum and the trachea, bronchi, esophagus and descending aorta in the posterior mediastinum.

Penetrating wounds of the heart and pericardium were covered by Maguire and Griswold at the 1947 meeting of The American Association for the Surgery of Trauma. In civilian practice the most important weapons are in order, the knife, pistol and ice pick. In military practice low velocity shell fragments were the most common cause of injury to patients admitted to hospitals since injury by high velocity projectiles is likely to result in immediate death. Penetrating wounds of the heart and great vessels may manifest themselves by (1) tamponade or (2) hemorrhage externally or into the thoracic cavities. Tamponade due to accumulation of blood under pressure within the pericardial cavity presents Beck's triad of acute cardiac compression. This triad consists of (1) falling arterial pressure, (2) rising venous pressure and (3) a small quiet heart. If a large rent in the pericardium allows decompression of the hemorrhage into the pleural cavities or if the wound involves extra-pericardial portions of the great vessels, the symptoms and signs are those of internal thoracic hemorrhage. In either case early emergency surgery is imperative except in the small group of patients with slowly developing tamponade which may be relieved by aspiration as suggested by Bigger and Blalock.

The surgical approach depends upon the location of the wound and the suspected internal lesion. Left anterior approach to the heart suffices in most cases and is carried out through a transverse incision with division or resection of one or more costal cartilages and a portion

of the sternum if necessary. Occasionally a right-sided or even a posterior approach to the heart may be indicated due to the location of the wound. The great vessels in the upper mediastinum may be approached by resection of the inner ends of the clavicle and appropriate portions of the upper ribs and sternum or by an upper sternal-splitting incision. Approach to the descending aorta is best made by a wide left transthoracic exploratory incision.

The pericardium is opened widely to expose the heart. The placement of a traction suture in the apex as advocated by Beck is of the utmost importance in controlling the heart during suture. Additional traction sutures may be used to rotate the heart for better exposure of the wound. Care must be taken in dislocating the heart, however, because of interference with cardiac function. Fine silk on small curved needles is the suture material of choice for wounds of the ventricle as well as the auricles. Due to thinness of the auricular wall and bleeding from the needle holes, gelfoam is a useful adjunct to suture in all wounds of the auricles and some wounds of the ventricles. As in all cardiac operations drainage is important to prevent postoperative tamponade. This is best accomplished by a wide opening between the pericardium and the pleural cavity to avoid the hazards of infection from external drainage.

Contusion of the heart was first emphasized by Beck and is probably of more frequent occurrence than is generally realized. In civilian life the most frequent cause of contusion is a blow on the anterior surface of the chest as from the steering wheel in an automobile accident, but contusion may also be caused by weapons or projectiles which penetrate the thoracic wall and bruise the heart. Samson found twenty-six cardiac contusions in wounds of the chest which were opened for other reasons. There was a 40 per cent cardiac mortality in his patients. Recognition of cardiac contusion from non-penetrating injuries may be difficult. The outstanding physical finding is a peculiar "tick-tock" heart sound and the

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finding of electrocardiographic abnormalities simulating coronary occlusion. Electrocardiograms should be taken in all cases of non-penetrating injury to the anterior thoracic wall. The treatment of cardiac contusion is similar to that of coronary thrombosis, that is, rest of the cardiac muscle until healing has occurred. Patching of the contusion with fascia lata or other material has been suggested by Beck.

Retained foreign bodies in the heart are rare in civilian practice. That such retained missiles are not uncommon in military life is shown by the excellent reports of Harken of 134 patients from whom missiles were removed from the great vessels, heart and pericardium. According to Harken such foreign bodies should be removed to (1) prevent embolism, (2) reduce the danger of bacterial endocarditis, (3) prevent recurrent pericardial effusion and (4) diminish incidence of myocardial rupture or hernia. In his hands the removal of such foreign bodies was a safe procedure and certainly should be carried out unless the foreign body is of minute size.

*Injuries to the Trachea and Bronchi.* Injuries of the trachea and bronchi may occur from penetrating and non-penetrating violence. They manifest themselves by hemorrhage into the trachea and by emphysema of the mediastinum which later spreads to the subcutaneous tissues. The air which escapes from the ruptured trachea or bronchus infiltrates the mediastinum, rises upward into the neck and becomes subcutaneous and may spread over the trunk as far as the lower extremities. This emphysema while extremely uncomfortable is rarely dangerous. It may be relieved by a low collar incision with blunt dissection into the antero-superior mediastinum to allow escape of air. The trachea should be kept clear of blood by bronchoscopic aspiration. Recovery is the rule unless there are associated fatal injuries. A late complication of rupture of the bronchus may be stenosis and resulting atelectasis which may require pneumonectomy or lobectomy.

*Injuries to the Esophagus.* The esophagus may be ruptured by (1) external violence by missiles or projectiles, (2) internal violence by swallowed foreign objects or instrumentation

or (3) spontaneous rupture from forceful vomiting, particularly in alcoholic subjects. Up until a few years ago this condition was almost uniformly fatal because of the ensuing septic mediastinitis. Proper use of sulfonamides and antibiotics has changed this picture along with a more aggressive surgical attack upon these injuries so that the prognosis today is fairly good. Primary suture of the laceration, with drainage of the surrounding mediastinum, is the method of choice in the early case but is seldom carried out because of delay in making the diagnosis before mediastinitis has occurred. At this stage x-ray examination will usually show widening of the mediastinal shadow and air in the periesophageal tissues. Barium studies should not be used as a diagnostic procedure. The proper treatment is withholding all food and fluids by mouth, administration of large doses of antibiotics and adequate exposure of the site of rupture by mediastinotomy with adequate suction drainage. In some cases, particularly those due to a missile or a weapon which injures the esophagus and trachea, there may be a resulting tracheo-esophageal fistula which may be closed after the infection is under control and healing is under way. If there is a communication with either pleural cavity, empyema will of course be a complication.

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# TRAUMATIC HERNIA OF THE DIAPHRAGM WITH STRANGULATION AND GANGRENE OF THE STOMACH\*

## REPORT OF TWO CASES

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MASS gangrene or acute localized ischemic necrosis of a stomach that has herniated through the diaphragm is apparently a very rare condition. Stuart Harrington<sup>1,2</sup> with a personal series of over 430 cases of diaphragmatic hernia recalls about six perforations of pressure ulcers in herniated stomachs but no case of gangrene of this viscus. Nor do the reports of other authorities in this field<sup>3-7</sup> mention specific instances of gangrene. In a cursory survey of English and American literature, including the excellent review by Carter and Giuseffi,<sup>8</sup> we discovered only five cases, including our own, of mass or localized gangrene of the stomach.<sup>9,10</sup> The explanation for this is probably the unusually rich gastric blood supply and muscularity. In contradistinction, the colon and small bowel are much more susceptible to strangulation and reports of gangrene of these viscera are not too uncommon.

### CASE REPORTS

CASE 1. L. H., a colored male laborer, aged thirty-seven, was admitted to Nichols Veterans Administration Hospital on April 10, 1948, with stab wounds in the epigastrium and in the left posterior chest in the seventh interspace, 4 cm. from the spine. Exploratory laparotomy at this time revealed only a small laceration of the left lobe of the liver. Admission chest x-ray showed no evidence of diaphragmatic hernia.

Following surgery the patient was remarkably free of pain and did not vomit but complained of shortness of breath. Physical signs and x-ray findings seemed to indicate a left hemothorax which reached the second left interspace. Daily thoracenteses withdrew 250 to 575 cc. of bloody fluid. Five days after admission the fluid became darker and had a foul odor; culture revealed anaerobic, hemolytic streptococci, *Staphylococcus aureus*, *B. coli* and *B. aerogenes*. X-ray now revealed an ex-

tensive area of density in the left thorax but in its center was a clear area with a fluid level. (Fig. 1.) The significance of this was missed at the time. The patient was spiking a temperature of 101.5° to 102.0°F. in spite of intrapleural and intermuscular penicillin.

On April 17, with a preoperative diagnosis of infected hemothorax, a left thoracotomy was carried out through the bed of the resected seventh rib. It was found that the stomach fundus had herniated through a 2½ cm. laceration in the posterolateral aspect of the diaphragm about 3 cm. from the esophageal hiatus. This protruded portion was black and gangrenous but intact and there was no obstruction of the stomach. The diaphragmatic defect was enlarged a few centimeters to allow delivery into the chest of the spleen and stomach well past the gangrenous area. The necrotic wall was excised and the stomach was closed. The stomach and spleen were then returned to the abdomen and the diaphragmatic defect was repaired. The layer of organizing blood clot and fibrin imprisoning the collapsed left lung was removed, allowing its full re-expansion. The chest was then closed around a catheter for suction drainage.

The patient had a protracted convalescence complicated by a gastric fistula through the thoracotomy wound but he did not develop peritonitis or appreciable empyema. On May 12th a small intrapleural abscess was excised and the fistula was closed. The patient was discharged from the hospital August 24, 1948. He returned to work about October, 1948, and when last contacted on May 6, 1949, he was in good health and free of complaints.

The features which obscured the true state of affairs in this case were the complete absence of pain and vomiting. Carter and Giuseffi<sup>8</sup> have pointed out the diagnostic value of bloody or serosanguineous intrapleural fluid in strangulated diaphragmatic hernias. In this case, however, the bloody fluid was interpreted as being

\* From the Surgical Service, Nichols V. A. Hospital and the University of Louisville School of Medicine, Louisville, Ky. Published with the permission of the Chief Medical Director, Dept. of Medicine and Surgery, Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the author.

a traumatic hemothorax later becoming infected. In retrospect, the diagnosis might have been suspected from the recent stab wound which could have lacerated the diaphragm but the correct interpretation of the x-ray (Fig. 1) showing a hollow viscus in the left thorax would have confirmed the diagnosis. It is interesting to note that strangulation and gangrene of the fundus caused no pain or vomiting in this patient. The probable reason for this astonishing lack of symptoms is that the stomach was not obstructed.

CASE II. O. W., a thirty-eight year old, white, male contractor, was first admitted to Nicholas Veterans Administration Hospital on October 10, 1947. In an auto accident he had fractured six left ribs (five through ten) near their angle and had sustained a severe head injury resulting in a left hemiparesis. X-ray of the chest (Fig. 2) taken at this time showed only the fractured ribs. While in the hospital the patient developed severe, deep thrombophlebitis of the right leg and thigh which was treated by anticoagulants.

On September 5, 1948, he was readmitted to the hospital with a tentative diagnosis of penetrating ulcer. For fifteen years he had had intermittent, ulcer-like, epigastric pain relieved by alkalies. These symptoms became worse in the two or three weeks preceding admission and the day before admission he was seized with a very severe, cramp-

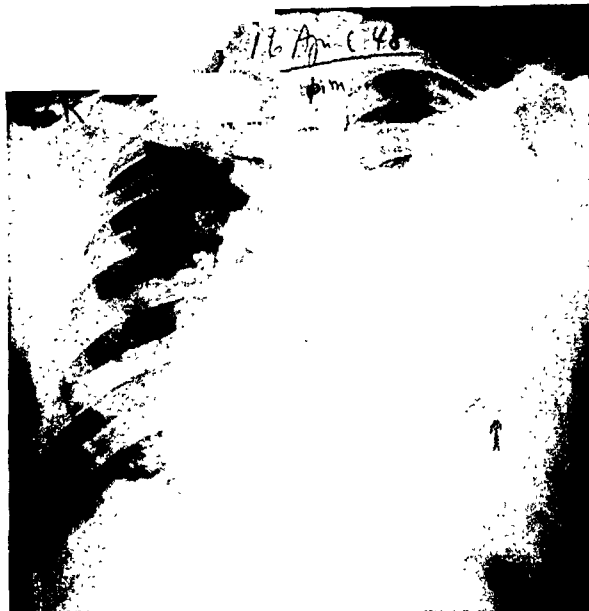


FIG. 1. Shows apparent massive left pleural effusion with displacement of heart to the right; arrow points to gastric bubble within left thoracic cavity. Case I.

ing, epigastric pain radiating to the right scapula and left shoulder. He was nauseated and vomited repeatedly.

Physical examination revealed an acutely ill male who lay flat in bed moaning and retching at frequent intervals. Chest findings were reported as negative. Abdominal examination revealed voluntary spasm in the upper abdomen and moderate to

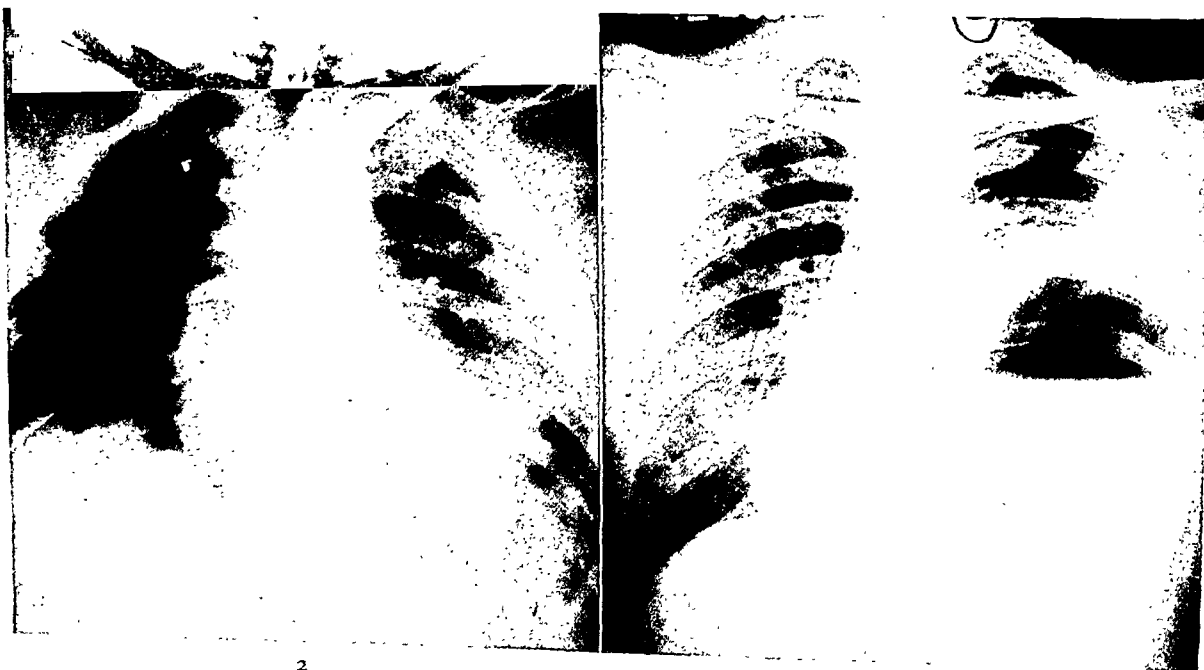


FIG. 2. Nothing definite to be made out in the illustration except for numerous fractured ribs on the left. Case II.

FIG. 3. This could be either eventration of left diaphragm or diaphragmatic rupture with stomach lying within the left thorax. Note also the displacement to the right of the mediastinum. Case II.

November, 1949

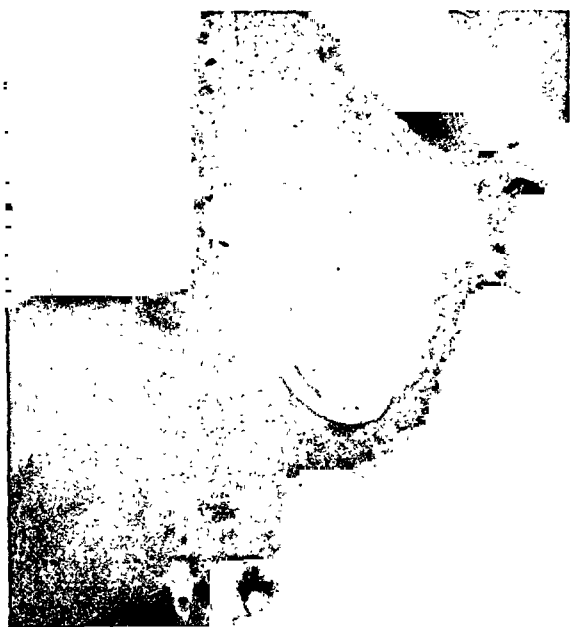


FIG. 4. Barium swallow reveals the high-lying stomach. This could be eventration of left diaphragm or herniation of stomach into left chest. Case 11.

marked tenderness in the epigastrium and gall-bladder area.

Admission laboratory data was normal except for white cell counts ranging from 18,000 to 26,000 with polymorphonuclears 85 per cent and for a trace of albumin in the urine.

A chest plate on September 8th (Fig. 3) revealed marked displacement of the mediastinum to the right and what appeared to be elevation of the left diaphragm to the second anterior interspace and a large gastric air bubble. A barium swallow on September 11th (Fig. 4) showed what still was interpreted by the roentgenologists as eventration of the left diaphragm containing a dilated, distorted stomach, possibly a gastric volvulus. Scout films forty-eight hours later revealed no passage of barium beyond the stomach. The patient continued to complain of severe pain in the epigastrium, chest and left shoulder and to vomit repeatedly in spite of Wangensteen suction. He began to hiccough and run a low grade fever. It now appeared that the probable situation was obstruction and incarceration of the stomach in a traumatic defect of the left diaphragm produced by the old chest injury.

On September 14th the left chest was opened through the bed of the resected eighth rib. In the left chest 200 to 300 cc. of hazy orange-brown fluid were found. The proximal half of the stomach was tightly incarcerated in a laceration of the diaphragm 5 cm. long, extending obliquely forward and to the left from a point about 2 cm. from the esophageal hiatus. (Fig. 5.) There were ischemic necrosis and marked edema of both the posterior

rim of the diaphragmatic defect and also of the imprisoned portion of the gastric fundus immediately adjacent to the cardia. The diaphragmatic defect was enlarged by incising the anterior end for about 6 cm. As the stomach was being freed, the necrotic area mentioned previously gave way and there was a spill of musty-smelling gastric contents mixed with barium. When the devitalized portion of stomach, cardia and adjacent esophagus had been excised, a defect was left in the anterior aspect of the esophagogastric junction about 7 by  $2\frac{1}{2}$  cm., leaving the esophagus attached to the stomach by a narrow bridge of wall  $1\frac{1}{2}$  cm. in width. (Fig. 6.) It was, therefore, necessary to divide the esophagus completely and reimplant it in the fundus of the stomach and to close the large defect left at the cardia. As it was impossible to approximate the rigid edematous margins of the diaphragmatic defect or to return the stomach entirely to the peritoneal cavity without undue tension, the margins of the unyielding diaphragmatic defect were tacked around the upper gastric fundus with interrupted cotton stitches as shown in Figure 7. This maneuver satisfactorily closed the diaphragm without any apparent distortion or constriction of the stomach. The lung was then re-expanded and the chest closed around a catheter for suction drainage.

Although the wound healed well, the patient did poorly. Already badly depleted, he developed a patch of pneumonia in the right lower lobe, homologous serum jaundice and a recurrence of thrombophlebitis in the right leg and thigh. The pneumonia and jaundice cleared up under appropriate therapy and the phlebitis was treated by left superficial femoral vein ligation and anticoagulants. When oral intake was resumed, the patient vomited most of what he received and a barium swallow revealed marked gastric atony similar to that seen after vagotomy for peptic ulcer. It was feared that the stomach might have again become strangulated so on September 28th he was re-explored through the original left thoracotomy incision. The diaphragm was found well healed around the upper gastric fundus without constricting or distorting it. Through a short gastric incision the esophagogastric stoma and the gastric mucosa were inspected and found to be normal, the stoma easily admitting two fingers. The thoracotomy wound was quickly closed and a Hendon type jejunostomy for feeding was then carried out through a short upper left abdominal incision. Palpation of the stomach below the diaphragm revealed no abnormality or abscess. The patient was returned to his bed but four hours later he suddenly died. Autopsy revealed massive right pulmonary embolism, the source apparently being the recurrent deep thrombophlebitis of the right lower extremity.

Although the ulcer-like background in this case caused some confusion at first, we should have diagnosed the condition earlier from the following features: (1) the history of a crushing injury of the chest which might have resulted in a rupture of the diaphragm; (2) the severe

## COMMENTS

Carter and Giuseffi<sup>8</sup> found that traumatic diaphragmatic hernias constitute over 90 per cent of cases complicated by strangulation. It might also be added that practically all diaphragmatic hernias are left sided. Of Harring-

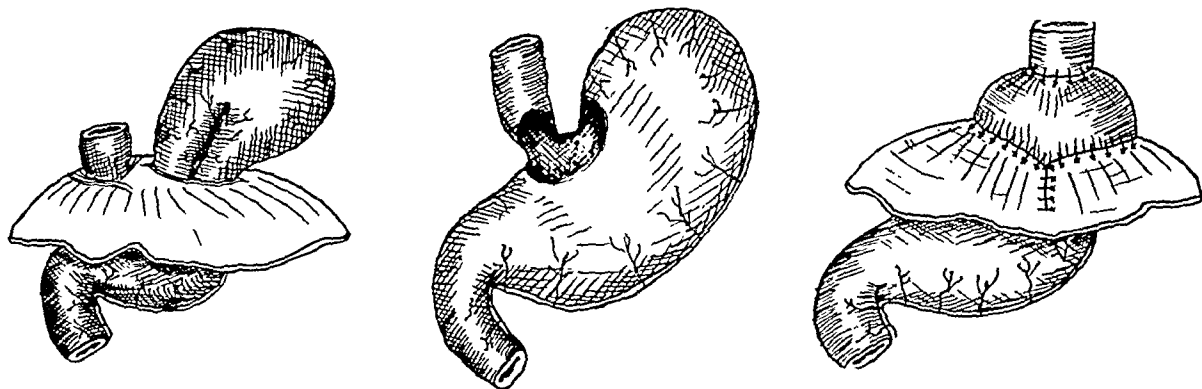


FIG. 5. Diagrammatic representation of proximal half of stomach incarcerated in rent in left diaphragm. Case 11.  
FIG. 6. Defect left when necrotic tissue resulting from pressure necrosis was trimmed away; the margins of this extensive defect were porky and edematous. Case 11.  
FIG. 7. Sketch representing reconstruction of esophagogastric continuity and repair of diaphragmatic defect by tacking diaphragm to upper gastric fundus; closure of defect in cardiac region not shown here. Case 11.

epigastric pain with suggestive radiation to the left shoulder; (3) the persistent retching and vomiting; unfortunately we cannot derive the full significance of this symptom since it was not accurately observed whether or not bile was present in the vomitus; (4) hiccough and (5) the x-ray picture. Although at first this was interpreted as eventration of the left diaphragm, it was equally indicative of a dilated stomach lying *above* the diaphragm.

It is interesting to note that this patient with a completely obstructing strangulation of the stomach had severe pain and vomiting although there was only localized pressure gangrene, whereas the previous patient remained symptom-free with non-obstructing strangulation and mass gangrene of the gastric fundus. Pathologic examination in this case confirmed our clinical impression that there was acute, localized, ischemic necrosis and not a perforated peptic ulcer at the site of pressure.

This patient unfortunately died of an unrelated condition. Nevertheless it would appear that the surgical repair itself was satisfactory and should be just as applicable to this condition as it is to the reconstruction following the "Sweet operation" for cancer of the esophagus or to esophagogastrostomy in resections of the proximal stomach.

ton's 430 cases, 98.4 per cent were on the left side.<sup>2</sup>

Certain characteristics of these strangulated diaphragmatic hernias are helpful in their diagnosis, namely, (1) history of an injury, crushing or penetrating, that might have lacerated the diaphragm; (2) pain, characteristically severe, usually located in the upper left abdomen and left chest and occasionally radiating to the left shoulder; (3) severe and repeated vomiting in most cases; it will be noted that these last two symptoms are no more than one would expect in any gastric or intestinal obstruction. The important thing is, in obscure cases, to consider the diaphragm as well as the inguinal canals or previous operative adhesions as possible sites of obstruction. In our review of forty-five case reports of strangulated diaphragmatic hernia we were interested to find that progress in strangulated diaphragmatic hernia toward gangrene or necrosis is not necessarily indicated by the severity of pain and vomiting. Thus 66 per cent of those patients with strangulation but no gangrene had severe pain whereas severe pain was present in 81 per cent of those who had progressed to gangrene. In like manner, 69 per cent of patients with strangulation only vomited repeatedly and severely whereas 81 per cent with strangulation and gangrene had



the same degree of vomiting. (4) As in other diaphragmatic hernias, varying degrees of dyspnea and respiratory distress may be present. (5) Suggestive chest signs are usually present. These include variations of tympany, dullness and adventitious sounds in the left chest and moderate to marked displacement of the heart to the right. (6) Bloody pleural fluid, as pointed out by Carter and Giuseffi, does not infrequently accompany a strangulated or gangrenous herniated viscus. (7) X-ray will usually be the final and sometimes the only diagnostic finding. Thus in our first case correct interpretation of the x-ray would have made the diagnosis in spite of other misleading findings.

The treatment of strangulated diaphragmatic hernia should be surgical as an emergency measure as soon as the patient can be prepared. There is still some difference of opinion as to the ideal approach but in the two cases presented and in the few others with which we have had experience we have been completely satisfied with the thoracic. This route seems to expose the pathologic condition most clearly and on several occasions it would have been virtually impossible to have dealt with adhesions and other disorders from an abdominal approach.

#### SUMMARY

1. Two cases of diaphragmatic hernia of the stomach with strangulation and gangrene are presented.
2. Strangulated traumatic hernia through the diaphragm is briefly discussed.

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#### DISCUSSION OF PAPERS BY DRS. BLADES, CAMERON, O'ROURKE AND BURT, IOVINE, GRISWOLD, AND HAMILTON AND PHILLIPS

E. J. O'BRIEN (Detroit, Mich.): I hesitate to discuss these papers because I heard only the last two of them. Dr. Blades (I imagine) told you what is uppermost in my mind, i.e., the similarity of the treatment of traumatic injuries to the chest and the postoperative treatment of all major thoracic surgery. One must always keep the air passages dry, watch for wet lungs, know how and when to block nerves to ease pain and facilitate raising sputum, encourage a patient to cough and help him by supporting the chest, etc. One must always be ready to bronchoscope and aspirate either air or fluid from the pleural cavity and to decorticate early if an organized pneumothorax exists.

I saw the last of the movie that Dr. Iovine presented on decortication and would like to emphasize its importance. In spite of all the papers by Drs. Blades, Tuttle, Burford, Langston and others, decortication is often delayed too long or a thoracoplasty is done to obliterate the pleural cavity. Many of these people get excellent results by freeing the lung from its thick visceral pleura so that it may fill the hemothorax and preserve some lung function. We get some startling results even in tuberculosis if the disease in the lung has not been too extensive.

I was very much impressed with Dr. Griswold's paper on injuries to the mediastinum and should like to add a word about injuries to the bronchi. In 1947 we read a paper in which we reported on a series of dogs upon whom a section of the bronchus was removed and the cut ends sutured. There was one on a human. These healed uniformly. When I was in Hawaii in January, Dr. Paul Gebauer had done four dermal transplants on humans to close the gap in the bronchus after a stenosis was resected. All patients did well. Since I came back we have operated upon numerous dogs using portions of trachea and bronchi to fill a gap in the bronchus. They all healed. In many we used specimens of trachea and bronchi that had been preserved for weeks. In some dogs as much as 2 inches of bronchus were resected and a preserved cylindrical specimen replaced. These wounds also healed.

Usually there is not much use in doing this procedure because the lung distal to a stenosis is usually bronchiectatic or destroyed, especially in tuberculous patients, but in traumatic stenosis or as a prophylactic measure after an injury I can assure you that it can be done with safety and with excellent results. It will save many individuals

from developing stenosis and will preserve many lungs.

HOWARD E. SNYDER (Winfield, Kan.): I looked forward to discussing this series of papers because I expected to hear something with which I should disagree. I did not.

I think they have emphasized one thing, namely, that the cardinal principle in treating a chest injury is relief of or avoidance of cardiorespiratory embarrassment whether it is by taking care of a sucking chest wound, a hole in the chest wall, aspiration of blood or fluid from the pleura, aspiration of blood or mucus from the trachea by one means or another, deflation of a dilated stomach, relief of pain by intercostal nerve block or, finally, the avoidance of strapping of the chest. All of them are designed to give the individual a cardiorespiratory mechanism which will work. They must be done as rapidly as possible and it must be remembered that any of them may be factors in shock and must be considered in dealing with the patient in shock.

I think the same principles may be carried over into the care of any surgical or injured patient, particularly one who has an injured abdomen or an abdomen which has had surgery performed upon it because the so-called wet lung, which is really the result of one or more of the factors mentioned, may develop in that patient as well.

L. M. SHEFTS (San Antonio, Tex.): I thought Dr. Cameron's paper helped to underline the statement made by Dr. Blades, that trauma certainly paid no attention to anatomic barriers; because when you realize the percentage of associated injuries that his patients had, the statement becomes very obvious. In the last World War, of 21,000 listed wounded soldiers 46 per cent had multiple injuries that is, important multiple injuries. A considerably smaller percentage is found in civilian practice.

I should like to say just one thing about wet lung. There is a great deal of talk about it and there is a great deal more talk than there is understanding. The mechanism by which it arises is not too well understood. I had certain ideas in Africa, changed them in Sicily and then changed them markedly near the end of the campaign in Italy. Many cases of wet lung will, in my opinion, promptly disappear if the patient is made to cough thoroughly from the very onset of this condition. Provisions must be made to insure relief from chest-wall pain when using intercostal blocks so that the patients will cough.

I think too many things are excused on the basis of the so-called wet lung. In the first place, if one pays attention to a clean, dry tracheobronchial tree and obtains and maintains it, there will be far fewer cases of so-called wet lung. I believe it starts on the inside and not from the trauma on the outside. In the process of treating other things

when opening chests, you see huge hematomas in the parenchyma of the lung and these patients do not have wet lung, whereas other patients suddenly get pulmonary edema. I think that eventually somebody will work out the exact mechanism of the thing but it is still far from answered.

One thing I should like to mention in relation to Dr. Cameron's excellent paper is that the subcutaneous emphysema he mentioned can be present without any rib fractures. It can be caused by rupture of the parenchyma of the lung, with air going into the interstitial tissues, the mediastinum, the neck and out over the body with a swelling-up like the proverbial toad. As Dr. Griswold pointed out, there are very, very few of those patients who ever need any incisions in the skin. I mention this only because I do not agree with the fact that these should be treated by trying to institute a local-area pneumothorax with decompression by catheter. I think if the pneumothorax space is not present by injury, for heaven's sake, do not make one! I think many of our complications arise from the fact that we sometimes cannot expand the lung to begin with. If it is expanded when we get it, leave it that way.

In reference to Dr. Iovine's paper I was amazed with the tremendous amount of material he covered in the short space of time. There is only one thing I should like to add to his fine paper. When the patient comes in with a penetrating or perforating wound of the chest, the question always arises in each case: Will this patient have to have surgery or not? The inexperienced person is very much upset by the patient coming in, short of breath, with hypertension, cold clammy skin, etc. Unfortunately in civilian practice many of those patients are taken to the operating room and operated upon. In a review of three different hospitals the mortality rate was almost a little less than twice the percentage of the mortality we had in field hospitals.

The difference was in one fact only. All the things that Dr. Iovine mentioned in the care of the patient, in a sense, might be called preoperative management. If that is all carried out, when you are through you often find that you do not have to operate upon the patient; that is, you stop the pain and let him cough to clear his tracheobronchial tree. One good cough by a patient is better than a bronchoscopy. If you can do that immediately, you will find that the blood pressure rises, the skin gets a little warm with a slight rosy tinge and the patient changes completely. But you do have to stop his pain to get him to cough; that is important.

After you have provided for the blood loss with blood and not plasma, I am convinced that there will be fewer operations for penetrating and perforating wounds of the chest than are so frequently done.

There are two other points I should like to make.

One is the matter of tension in the thorax. We listed in our series in the surgical group that Dr. Iovine spoke about, the Second Auxiliary Surgical Group, a large number of tension pneumothoraces. I began taking pleural readings on every patient who came in and I discovered a very interesting fact, namely, if a reading is taken on every one of the patients with a hemopneumothorax, it will be seen that these patients have a positive pressure, at least on their expiration if not on both inspiration and expiration. They may not necessarily be short of breath. On many occasions if you aspirate them, take a reading and then remove the blood, you will find that the so-called tension pneumothorax was never a tension pneumothorax at all and would not be.

In my own personal series of 265 major thoracic injuries I had only three tension pneumothoraces that answered those rules, that is, three in which I had to go back in and retap. Without an increase of blood pouring into the chest, thus increasing the pressure of the air, the second or third reading showed a definite and sudden build-up of pressure. When tension pneumothoraces have to be decompressed, they are not to be decompressed by a needle. This is the only thing on which I would disagree in the slightest with what Dr. Iovine has said. It is too haphazard; it shuts off too quickly. If a tension pneumothorax must be decompressed, it must be done with a catheter and a good sized one, hooked up to a water trap bottle.

I should like to be slightly presumptuous and suggest a method about which Dr. Griswold spoke concerning injuries to the esophagus. There is a combined method of suturing the esophagus and draining the mediastinum at the same time. If one goes in on the right side (which, of course, is a fortunate side on which to handle an esophageal tear) and finds a tear in the esophagus, a suture of the esophagus is done primarily. With the patient on his left side, a long, 3-inch needle is shoved out in the intercostal space, right through the back; the hub is shoved right down into the intercostal space and pleura, a rubber drainage tube is packed in there, too, and then the mediastinal pleura is closed. The chest is then closed, the lung expanded and an incision is made around that needle and a small segment of rib removed. When you reach in and pull out the rubber drain, you have an extrapleural mediastinal drainage of the sutured side of the esophagus.

LESTER BREIDENBACH (New York, N. Y.): Speaking of hemothorax, Dr. Tillett at New York University has developed a material, which is a metabolic product of streptococci, which he has called streptokinase and streptolysin. We have had some small experience with this material in that we aspirated the blood from the chest cavity and applied the streptokinase or streptolysin (he now calls it streptokinase) which has the faculty

of setting up an enzymatic or anti-enzymatic process which dissolves the fibrin; then twenty-four or thirty-six hours later the chest is re-aspirated and the fibrin remains entirely liquid.

By that particular method of treatment none of these patients who have been treated that way with this new material has developed an organizing hemothorax which required decortication later. It is apparently going to work or is working very efficiently. The experience has been with only about thirty patients, two of whom I have seen treated on our service. Both did very well with expansion of the lung very quickly so that none of them ever required decortication.

DUNCAN A. CAMERON (closing): I should like to thank all of the discussers for their comments. I believe only one or possibly two specific points were directed to our paper in particular. The first was the question in the discussion of Dr. Shefts having to do with the placement of a thoracotomy tube in the treatment of rapidly progressing subcutaneous emphysema which we had commented upon. His comment was that we should leave that pleural space inviolate.

The reason why we have used this thoracotomy tube was that we had a specific location for the supposed injury to the lung, at the site of the fractured ribs, and we believed that there was an associated pneumothorax although the roentgenogram did not show it. We have noted that with pneumothorax the placement of a thoracotomy tube generally is followed by a subsidence of all ordinary subcutaneous emphysema. We have used this method on a couple of occasions and it has seemed to work so we have concluded that there was a pneumothorax space present although it did not show in the x-ray.

As for the wiring of fractured ribs, I think our only comment is that we were interested in analyzing multiple fractures of the ribs not from the standpoint of the ultimate healing of the rib itself, which in 109 cases was never of any concern to us; but we were interested instead in pointing out that multiple fractures of the ribs are as serious a problem from the standpoint of disturbance of cardiorespiratory physiology and the complications which follow in the pleural space.

JOHN C. A. GERSTER (New York, N. Y.): Dr. Blades, I do not think Dr. Jones made himself clear. What he talked about was the sucking wound with a number of ribs each broken in two places. In their series at Richmond the doctors immobilized such sucking wounds of the chest wall by wiring of adjacent rib ends. There was great comfort immediately after such wiring of the ribs.

VINCENT M. IOVINE: (closing) I should like to answer Dr. Shefts' comment first on the question of the use of simple apparatus, such as I mentioned, for decompression of a pressure pneumothorax. I thought I made the point that that was strictly

an emergency procedure and certainly the use of the intercostal catheter is much to be preferred if it is available. I did state that under field conditions the most available thing was usually a fairly large needle which works effectively until the underlying pathologic disorder can be straightened out.

I am not sure I understood the question of the last commentator. I do not see actually, however, if this answers the question, how wiring of multiple fractured ribs would guard against paradoxical respiration in a patient with a severely injured chest wall and a crushed chest. I think Dr. Cameron pointed out the type of immobilization that was necessary and the application of the particular type of instrument he used in conjunction with the use of traction.

The value of Dr. Cameron's paper, I think, is in emphasizing the physiologic approach to the treatment of severe chest wounds. He certainly has presented the proper attitude toward strapping of the chest and the proper treatment of the complication usually called "wet lung."

Occasionally unusual complications accompany fractured ribs and I will briefly outline one of those. A twenty-one year old Air Corps gunner entered the Walter Reed Service complaining of two and a half years of intermittent and recurrent hemoptysis. Fairly close questioning into the past brought out no history of trauma at first. He had been examined extensively from the point of view of acid-fast infection and had all the indicated procedures performed in an effort to determine the origin of the bleeding.

On careful examination of the x-ray film of his chest, a small defect in the sixth left rib was revealed and, following repeated questioning, it was learned that he had received some chest injury in the process of his extensive and severe training for his job. He was, therefore, explored and at operation a single rib fragment was found still attached at its broad base on the left to the inner aspect of the rib and the thin, sharp edge of the opposite end was impaled into the superior segment of the left lower lobe. Surrounding it there was a foreign body reaction and a small abscess. Following wedge resection of the area and removal of this foreign body, his hemoptysis ceased. I have been able to follow him four years through the Veterans' Hospital facilities and he has had no recurrence since.

R. ARNOLD GRISWOLD (closing): I should like to thank Dr. O'Brien and Dr. Shefts for their suggestions in regard to repair of the old stenosed bronchus and extrapleural drainage of the esophagus.

In regard to Dr. Jones' question I certainly agree with Dr. Iovine that a much simpler method of stabilizing the chest wall in these multiple parallel fractures and preventing paradoxical respiration is traction rather than wiring.

Traction is very easily applied by simply putting a towel clip around the rib, running it up to a pulley and hanging a weight over it. You do not need a lot of fancy apparatus. A towel clip will do it and in just a few moments will change the entire picture in these patients.

BRIAN B. BLADES (Washington, D. C.): The discussions concerning the treatment of ruptured bronchi have been extremely interesting. It might be worth while to emphasize one point which is sometimes helpful in making a preoperative diagnosis. Consideration of a ruptured bronchus should be entertained in the case of a patient who has had trauma to the thorax in whom there is no visible evidence of rib fracture but the patient has a tension pneumothorax with associated emphysema. This is particularly true if the subcutaneous emphysema precedes development of the tension pneumothorax.

Another comment I should like to make concerns the mediastinum. After any trauma to the mediastinum, particularly after the most common form in civilian life, namely, rupture with the esophagoscope or tearing with chicken or fish bones, there are two important factors to be considered: first, mediastinal pressures and second, the development of infection.

If there is a large rent in the mediastinal pleura, air leaking from the esophagus may enter the pleura and produce a pneumothorax. If, however, the rent in the esophagus has not injured the mediastinal pleura, the immediate leak of air and fluid into the mediastinum can produce a mediastinal tamponade with a fatal outcome in a very short period, certainly long before infection becomes an important factor. This is, of course, one of the principal reasons that suspected mediastinal injury, particularly injury to the esophagus, constitutes a real surgical emergency.

The last comment I should like to make concerns the use of gelfoam in cardiac surgery, particularly when the auricles are injured. Dr. Griswold has already mentioned its usefulness when needle holes produce bleeding in heart wounds after their repair. The late Horace Smithy, who revived and pioneered the very brilliant and brave work on the surgery of cardiac valves, had an amazing experience which is worth recounting. During his performance of the operation which involved inserting an instrument through the ventricle to cut a stenotic mitral valve, the valvulotome was inadvertently pushed through the valve and appeared in Doctor Smithy's hand beneath the heart after perforating the wall of the auricle. A large sheet of gelfoam was placed under the heart and held against the auricle and the bleeding was controlled. The patient survived and had an excellent result. This illustrates the dramatic usefulness of gelfoam when auricles are injured.

JOHN E. CANNADAY (Charleston, W. Va.): With reference to the presentation of Dr. Johns of Richmond, Virginia, with regard to the treatment of rib fractures by wiring, I was present with a group of surgeons at White Sulphur Springs a few months ago when Dr. Coleman of Richmond and others presented a method of treating fractures of the ribs as they would fractures of other long bones. To make it short, they were approximating the broken ends of the ribs and wiring them.

In the case of consecutive multiple fractures of the ribs, they usually made a long, more or less vertical incision exposing the fractures and wired each rib at its point of fracture. In other cases of multiple fractures they may make a U-shaped incision so as to expose the double fractures of several consecutive ribs.

I talked also with a number of members of the surgical staff of the hospital of the Medical College of Virginia where they have adopted the method as a routine and are treating all fractures

of the ribs in that manner. They state that the period of convalescence has been greatly shortened and that the patients have been made infinitely more comfortable than heretofore. A person who has not had a fractured rib does not realize the discomfort and pain incident to it and the prolonged soreness incident to slight movements of the rib. Having had a fractured rib myself, it is my opinion that the use of adhesive strapping greatly adds to the discomfort. I believe that the fixation of the fractured rib, treating it as one would the fracture of a long bone elsewhere, has a sound basis of merit behind it. In regard to the hazards incidental to rib fractures I recall that some of the older English surgeons used to say that fracture of six consecutive ribs usually was followed by death. They commented thus when the body of a Roman soldier was exhumed somewhere in England and it was found that he had had six or seven consecutive fractured ribs and had recovered.



# THORACICO-ABDOMINAL APPROACH TO RUPTURE OF THE LIVER\*

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**F**ORTUNATELY, massive rupture of the liver following trauma is not common but the condition must be given serious consideration since failure to handle it quickly and competently almost invariably means the loss of a life. The signs and symptoms are those of intra-abdominal hemorrhage; a differential diagnosis as between rupture of the liver, rupture of the spleen and a torn mesenteric vessel cannot usually be made. However, in any case it is obviously necessary to open the abdomen without delay.

The patient is usually in shock and should be given intravenous therapy in the form of plasma and whole blood as soon as possible. The stomach contents should be emptied through a Levin tube. In fact this should be done in all such cases of emergency surgery since it is not uncommon for these patients to have their stomachs filled with a conglomeration of hot dogs, coco-cola or beer at the time of their injuries. If the patients should vomit while under anesthesia, a small amount of this vomitus aspirated into the trachea might cause death.

Before the incision is made, the surgeon should, if possible, be well fortified with 4 to 5 pints of whole blood. The anesthetist should be prepared to insert an intratracheal tube or at least carry the patient on positive pressure anesthesia in case it should be necessary to enter the thoracic cage. Either a right or a left rectus incision is made depending on the point of maximum tenderness. From this incision it is usually possible to determine the nature of the injury. If the tear in the liver is small and easily approached, it is usually sufficient to pack it with one of the absorbable sponges which should be held in place by an absorbable suture placed with an atraumatic needle. However, in cases of severe lacerations and especially those extending to the more inaccessible areas of the liver, it is often impossible to control the hemorrhage from this approach and it

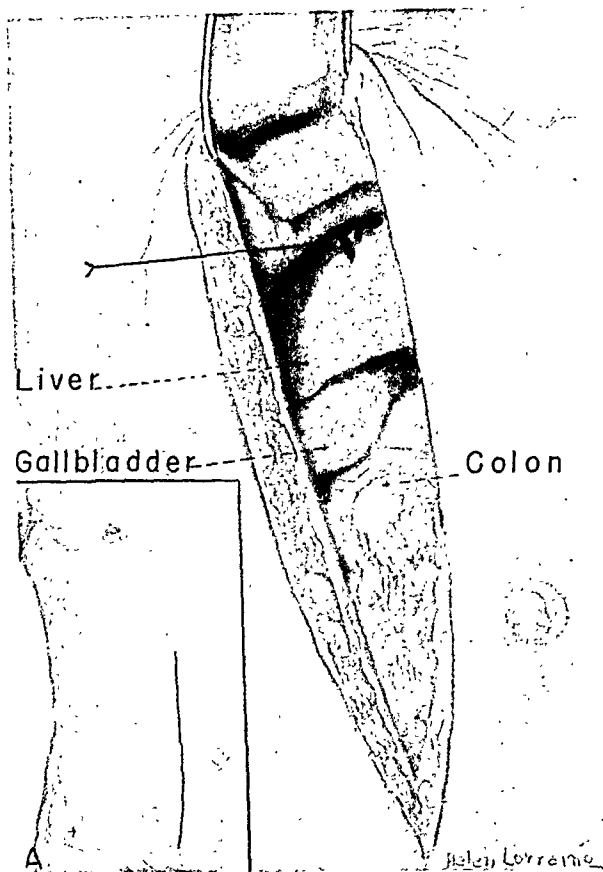


FIG. 1. Arrow points out the lower end of the laceration that could only be visualized by lifting up the upper end of the incision with a right angle retractor; insert A; the right rectus incision used.

becomes imperative to secure a more adequate exposure. For this purpose the thoraco-abdominal incision is the ideal procedure. It gives remarkably good exposure and is well tolerated under positive pressure anesthesia. Every surgeon who cares for trauma patients should be familiar with the incision.

One of us (J. W. D.) first learned of this incision from Chamberlain<sup>1</sup> while working with him in Okinawa. The historic development of this type of incision was covered by Carter<sup>2</sup> who describes in detail not only his own incision but the variations used by several other surgeons.

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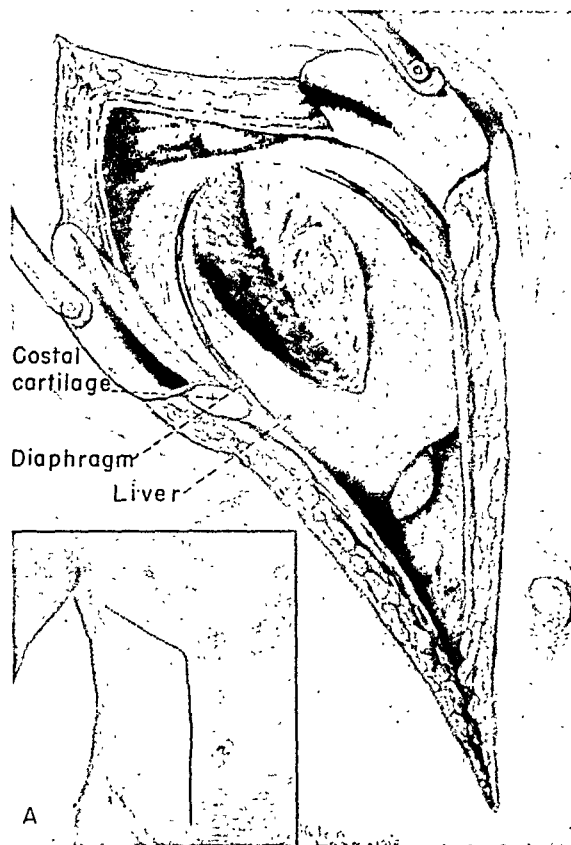


FIG. 2. The thoracic extension between the fifth and sixth ribs; right lung collapsed; diaphragm opened showing exposure of extensive laceration of liver.

Harper<sup>3</sup> has also recently described this type of incision which he has used successfully in several different types of cases including three diaphragmatic hernias. MacManus<sup>4</sup> and Garlock<sup>5</sup> have used it in operating upon neoplasms of the cardia and esophagus. All report with considerable enthusiasm on the results obtained. In traumatic surgery the exact type and location of the incision will vary with the individual injury.

We wish to report an illustrative case in which the massive hemorrhage, in our hands, could not have been controlled without the use of the thoracico-abdominal approach.

#### CASE REPORT

The patient, an eighteen year old male, was admitted to the hospital on February 21, 1948, an hour after he had been injured in an automobile accident. He had been thrown from a truck in such a way that his body had been wrapped around a wooden post. The patient had been in a semi-conscious condition and had not spoken since the time of his injury.

Examination showed a well developed, well nourished eighteen year old male who moaned and held his abdomen but would not respond to questions. There were some abrasions about the neck and face. The chest was clear to percussion and auscultation. The heart was not enlarged and there were no murmurs. The sound was distant, the rate rapid and regular. Blood pressure was 90/40. There were no obvious fractures or dislocations. The neuromuscular reflexes were sluggish but present and equal. The patient had pediculosis pubis. There seemed to be more tenderness in the right side, but the entire abdomen was held rigid, and the patient did not respond sufficiently for the tenderness to be definitely localized. X-rays were of no diagnostic value. A catheterized urine specimen showed gross blood. The blood picture was 3,230,000 red blood cells, 21,650 white blood cells, 10.2 Gm. or 66 per cent hemoglobin, 82 polymorphonuclear leukocytes and 18 small monocytes.

The patient was given plasma while in the accident room and, fortunately, 3 pints of whole blood which matched the patient's were available in the blood bank. These were administered during the course of the operation.

A right rectus incision was made under satisfactory general anesthesia. (Fig. 1.) The peritoneal cavity was found to be filled with blood. The spleen and mesentery were intact, and the anterior portion of the liver appeared to be normal. However, exploration up under the dome of the diaphragm revealed that the right lobe of the liver was almost completely severed, leaving two profusely bleeding liver surfaces, approximately 5 inches in diameter on each side. A large laparotomy sponge was placed in the laceration but bleeding continued to be profuse. Only the lower end of the laceration could be visualized by lifting up the upper end of the incision with a right angle retractor.

At this point the nurse anesthetist was told that we were going to enter the thoracic cage. Unfortunately, no one was immediately available to insert an intratracheal tube. Under positive pressure anesthesia the incision was extended up to approximately the sixth rib. The costal margin cartilage was cut through and the thoracic cage entered between the sixth and fifth ribs. The diaphragm was cut between Kocher clamps, thus exposing the dome of the liver. (Fig. 2.) The hemorrhage was controlled by placing the hand beneath the liver and packing the laceration with twelve gelfoam sponges. Interrupted mattress sutures of chromic catgut were placed in the liver. (Fig. 3.) This was reinforced with two-inch gauze packing which was brought out through the abdominal incision. Further exploration revealed that there was a small amount of retroperitoneal bleeding in the region of the right kidney. The operative wound was closed by using continuous catgut sutures for the peritoneum and pleura and continuous chromic

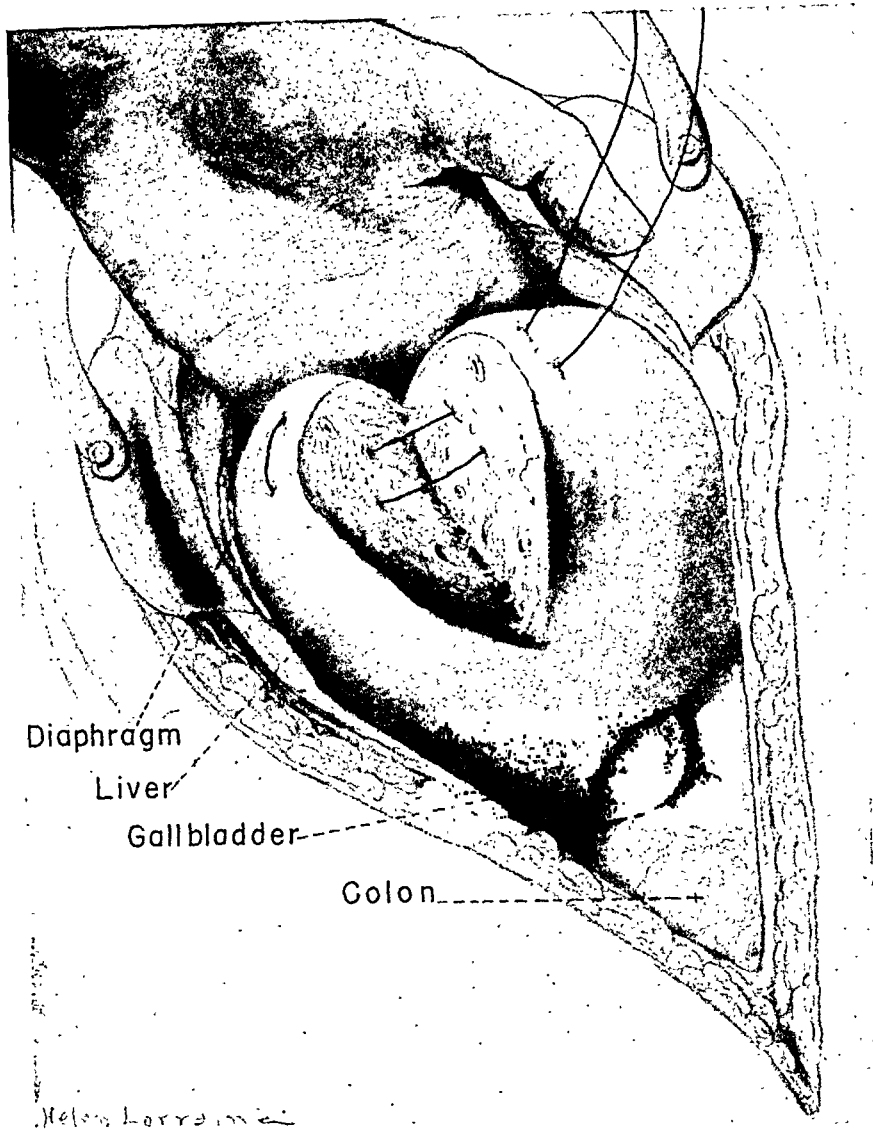


FIG. 3. Illustrates how the hemorrhage was controlled and the liver sutured.

catgut reinforced with interrupted chromic sutures for the fascia and intercostal muscles. The skin was then closed with interrupted black silk sutures. The chest was closed without drainage.

At the end of the operation the patient's blood pressure was 110/90 and his pulse was 140. His condition was considered critical but better than it had been at any time since the accident.

In addition to the three pints of blood administered during the operation, the patient was given another 500 cc. the following morning. Penicillin was administered in doses of 100,000 units every three hours from the time of admission on February 21st until April 1st, then in doses of 50,000 units every three hours until April 17th. On February 24th (the third postoperative day) the patient's blood count showed 3,540,000 red blood cells and 10.05 Gm. or 71 per cent hemoglobin. On February 27th (the sixth postoperative day) the gauze packing was removed under pentothal anesthesia.

For the first two or three postoperative days the patient was irrational and removed his bandages several times attempting to scratch the pediculi before they were eradicated resulting in a wound infection. If treatment of the pediculosis had not been overlooked due to our attention being focused on the more glamorous aspect of this case, the wound infection would probably not have occurred. A localized empyema also developed which cleared up promptly following open drainage by resecting 1 inch of the eighth rib. This complication might have been prevented by suction drainage of the chest for a few days following operation.

The patient was followed during his postoperative course by the medical service. In regard to hepatic insufficiency it was their opinion that he showed no signs of this. The hematuria cleared up without treatment. The patient was discharged after sixty-one days' hospitalization. He has been seen each month since that time and is now





FIG. 4. The patient seven months postoperatively showing the healed scar; the cross marks illustrate the thoracic extension.

symptom-free, has gained weight and is back at work. (Fig. 4.)

#### SUMMARY

No claim of originality is made for the thoracico-abdominal incision. It was demonstrated to me by Chamberlain while working with him in Okinawa. But we consider that its application in case of liver trauma offers such marked advantages that any surgeon who cares for trauma patients should be familiar with the procedure. The exact type and location of the incision will depend upon the individual injury. In the case presented a severe laceration of the right lobe of the liver was successfully repaired through a thoracico-abdominal incision. We believe that no other

approach would have given the necessary exposure.

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# MASSIVE RUPTURE OF THE LIVER\*

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IN civilian medical practice massive rupture of the liver is fortunately a rare clinical problem. It is not that the entity is uncommon in this era of speedy aerial and surface transportation for it occurs often in immediately fatal airplane and automobile accidents. Nevertheless, on any list of hospital admissions massive rupture of the liver presents a very low incidence since most patients expire immediately or shortly after the accident.<sup>1-4</sup>

Increased knowledge of indications for exploration in closed abdominal injuries, availability of blood, blood fractions and blood substitutes, and development of antibiotic therapy to its present high level have improved the surgical management of these cases. Resection of large masses of hepatic tissue or even complete resection of the left lobe of the liver for tumor is now being done with an acceptable mortality by means of meticulous surgical technics.<sup>5-8</sup> However, repair or reconstruction of the massively ruptured liver with adequate control of hemorrhage still remains nearly unsurmountable. Extensively pulped or lacerated liver tissue is quite impossible to suture satisfactorily even with the most meticulous of technics. Recurrent or secondary hemorrhage, often fatal, attends the most earnest effort at hemostasis. Failure to débride non-viable liver tissue may result in sequestration, sepsis, secondary hemorrhage, hepatorenal decompensation and death.<sup>11-17</sup> The over-all mortality of liver rupture in general remains around 60 per cent, that of the massively ruptured cases being very much higher.<sup>2,4,9</sup>

At the present level of development of surgical technic, adequate débridement and reconstruction of such massively ruptured livers is thwarted mainly by the lack of a safe and effective technic for hemostasis; it is generally believed that hemostasis is the greatest single problem in hepatic surgery.<sup>2,9</sup> Recent reports have strongly recommended the use of oxidized cellulose and gelatin sponge alone or in com-

bination with soluble thrombin as hemostatic agents in hepatic surgery.<sup>10</sup> Sano and his co-workers have described a coagulum-contact, non-suture technic of repairing hepatic defects with impressive experimental evidence of its efficacy. Jenkins et al. have also presented evidence of the effectiveness of gelatin sponge and soluble thrombin solution in experimental hepatic and cardiac surgery in animals and in human patients after surgical biopsy of the liver.<sup>18-23</sup>

## CASE REPORTS

The following two cases of massive hepatic rupture with survival in which a similar non-suture technic of débridement and hepatic reconstruction was employed illustrate certain advantages and disadvantages of these methods in surgical practice.

CASE 1. M. A., a twenty-six year old white male was crushed between an overturned loading truck and a heavy concrete guard rail at 12:45 P.M. on April 30, 1947, about thirty minutes after eating a heavy lunch of meat, potatoes, beans and pie. He was able to extricate himself and walk a few steps but he then collapsed with pain in the abdomen and chest. When examined ten minutes later he was quite pale, restless and seemed hysterical. He complained of severe right upper abdominal pain and of pain in the right shoulder of a deep aching intensity (Kehrer's sign). There was an area of contusion and ecchymosis over the right lower thoracic cage in the mid-axillary line. His abdomen was board-like. His pulse was 100 and his blood pressure 130/80. He was not nauseated. Despite the board-like rigidity there was exquisite tenderness in the right upper abdomen and right flank as well as generalized tenderness throughout the entire abdomen.

At the plant dispensary plasma was immediately started intravenously. With it running continuously the patient was brought to the hospital by ambulance. It was believed that the patient had suffered a rupture of the liver and, possibly, of the food-filled stomach.

On admission to the hospital preparations were

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made for the transfusion of whole blood. Because the patient's blood pressure had been well maintained on the ambulance trip to the hospital, he was taken immediately to the operating room where a continuous whole blood transfusion was started and an exploratory laparotomy was begun less than an hour after receipt of the injury.

An extensive transverse incision was made in the upper abdomen revealing two tremendous stellate lacerations involving about two-thirds of the right lobe of the liver. There were about  $2\frac{1}{2}$  pints of free and partly clotted blood already in the upper abdomen and fresh bleeding was issuing from several large lacerations. There were two major clefts in the right lobe of the liver which extended vertically from the free inferior margin of the right lobe over the diaphragmatic surface or dome of the liver up to the coronary ligament. The more lateral of the two clefts practically amputated the lateral third of the right lobe of the liver. The medial cleft was exceedingly deep and nearly transversed the entire thickness of the liver in an anteroposterior direction. The entire hand could be laid within this cleft with ease. From these two major clefts innumerable smaller fissures extended in all directions involving an area estimated to be at least two-thirds of the right hepatic lobe. In and around all of the larger fissures was a quantity of pulped liver tissue mixed with clotted blood which was removed with the suction tip much as the neurosurgeon removes a highly cellular brain tumor. Because the viability of the partially amputated lateral third of the right lobe was extremely doubtful, it was decided to complete the amputation by resection. The raw surface left by this procedure was covered with a large, dry sheet of oxidized cellulose gauze (oxycel) held pressed in place by means of a warm lap sponge. The gallbladder was collapsed due to the recent meal; but since the medial cleft passed beneath it, it was impossible to be sure that the gallbladder was not torn or severely damaged on its hepatic surface. Consequently, a cholecystectomy was done. The gallbladder proved to be intact although its bed was severely torn.

The comminution of the right lobe of the liver was so extensive that suturing in any form was out of the question. Consequently, the remaining large medial cleft and the innumerable fissures of all sizes radiating over the right lobe were packed with thin, dry sheets of oxidized cellulose gauze (oxycel). The liver was then manually compressed so that all fragments were moulded together.

With the liver compressed in this fashion and held thus by the first assistant, a thorough upper abdominal exploration was carried out, mobilizing the hepatic flexure of the colon, the retroperitoneal duodenum, the head of the pancreas and the retroperitoneal common duct. These structures were examined carefully for injury but none was found. The stomach, transverse colon, both kidneys

and the spleen were then examined for injury. Except for an area of contusion over the upper pole of the right kidney no other injury was discovered. There was a very large and extensive retroperitoneal hemorrhage on the right side of the vertebral column apparently arising from the liver near the dome and dissecting between the surfaces of the coronary and diaphragmatic attachments of the liver downward. At the end of the abdominal exploration, which took approximately thirty minutes, compression of the liver was discontinued and the liver was re-examined; it was found that the numerous smaller fissures seemed to be sealed off quite effectively and that the two large fragments of the right lobe divided by the major vertical cleft were held in apposition satisfactorily by the now tenaciously adherent oxidized cellulose gauze. There was no evidence of continuing free bleeding or of free biliary drainage.

The upper abdomen on the right side was then extensively drained by means of numerous large Penrose drains placed down to and into the foramen of Winslow, the right anterior and posterior subphrenic spaces, the right subhepatic space and the pouch of Morrison. A Levin tube was inserted into the food-filled stomach and the abdomen was then carefully closed in layers using interrupted silk sutures throughout. The patient endured the operative procedure surprisingly well and showed no evidence of shock.

The postoperative course during the next thirty-eight hours was marked by restlessness and gastric distention but shock or shock-like manifestations did not appear. Because of the undigested solid food mass in the stomach gastric suction was very inefficient and required continuous and arduous irrigation and lavage by the special duty nurse. At thirty-eight hours postoperatively, during a convulsive paroxysm of coughing, wound dehiscence and evisceration occurred. The patient was immediately returned to the operating room where, under anesthesia, dressings were removed revealing a wide rupture of the wound and the evisceration of most of the dilated stomach, the entire transverse colon and three loops of jejunum. Examination revealed that all of the silk sutures were in place, knots intact, but that the strands had actually ruptured or snapped under the force of the coughing. The viscera were replaced and the abdomen was closed with through-and-through steel wire sutures. The patient bore the procedure remarkably well. It is of interest that no free blood of any consequence or any sign of continuing hemorrhage or of general biliary drainage was seen during this procedure. A partial inspection of the right lobe of the liver was afforded at this time and the repair seemed intact.

Following this the postoperative course was marked by restlessness and some distention but signs of peritonitis did not appear. There was

profuse biliary drainage from the right lateral angle of the incision along the drains but the drainage was never bloody. Indeed, from the twelfth hour after the initial operation bloody or serosanguineous drainage was never in evidence.

Throughout this period supportive transfusions

had been done, leaving a raw surface covered with oxidized cellulose gauze. Irrigations through the tubes were at first effective in clearing out this drainage. However, by June 3, 1947, five weeks after the accident and initial operation, there was definite clinical and x-ray evidence of a right

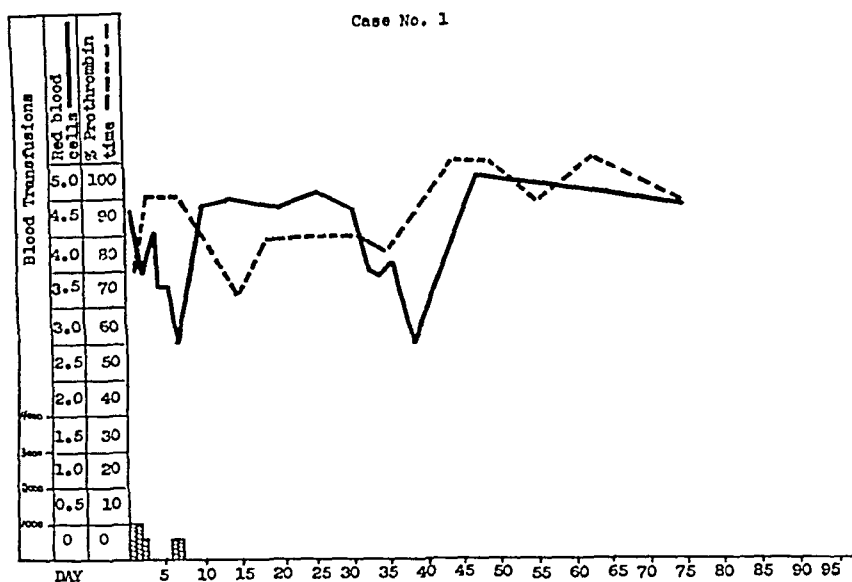


FIG. 1. Red blood count and prothrombin levels in Case 1; whole blood transfusions indicated by cross-matched columns.

of blood and plasma had been given and the parenteral administration of liver extract, vitamin B complex, vitamin C and probably excessive amounts of vitamin K had been pushed. Carbohydrate was provided parenterally by infusions of glucose solutions, protein by the infusion of plasma, whole blood or amino acid mixtures. Fibrinogen and prothrombin were supplied by transfusion of freshly drawn whole blood. By the sixth postoperative day and the fourth postevisceration day the abdomen was soft and non-distended. The patient was passing flatus freely per rectum. Nasal suction was discontinued; the tube was allowed to remain and small tube feedings of a casein hydrolysate mixture with liberal amounts of added choline and methionine were begun. (Fig. 1.)

Biliary drainage continued to be profuse and small fragments of autolyzed, sequestered liver tissue began to extrude along the drains. By the tenth postoperative day the patient was up in a chair, had begun to be ambulatory and to take a high protein, high caloric diet by mouth. The temperature curve continued to be irregularly elevated and a profuse, rancid drainage with numerous small fragments of autolyzed liver tissue continued in abundance. Penrose drains in the right posterosuperior subphrenic space were replaced by soft rubber tubes. The drains to other areas were gradually removed completely. It was then noticed that the rancid drainage was coming exclusively from the region in which the resection of liver tissue

posterosuperior subphrenic abscess which was not being adequately drained by the rubber tubes which barely reached this pocket. Consequently, surgical drainage of this subphrenic abscess was accomplished at this time by resecting the entire twelfth rib and a portion of the eleventh rib on the right side, entering the right posterosuperior subphrenic space extraperitoneally. A large amount of rancid, necrotic pus was evacuated. The abscess was drained extensively with numerous Penrose drains and a large soft rubber catheter. During the next two weeks the Penrose drains were removed one by one, leaving in place the soft rubber catheter. Irrigations, at first of normal saline solution and later of freshly prepared Dakin's solution, were carried out daily through the catheter, and the steady closure of the abscess cavity was closely followed by means of repeated x-ray studies with instillation of iodized oil. The patient continued to improve and gain weight and was discharged from the hospital on July 3, 1947, sixty-four days after injury, in good physical condition and with a soft rubber catheter still in place in a small residual pocket in the right posterosuperior subphrenic space. Treatment continued with daily irrigations in the office as an outpatient and during the next ten days the small pocket in the subphrenic area closed completely and permanently. During the next five months the patient continued to gain in appetite, weight and strength; laboratory evidence of hepatocellular

damage as manifested by the cephalin-cholesterol flocculation test disappeared slowly but completely. He was able to return to light work at his plant eight months after injury. (Fig. 2.)

On January 10, 1948, the patient was subjected to a prolonged operative repair of a very extensive

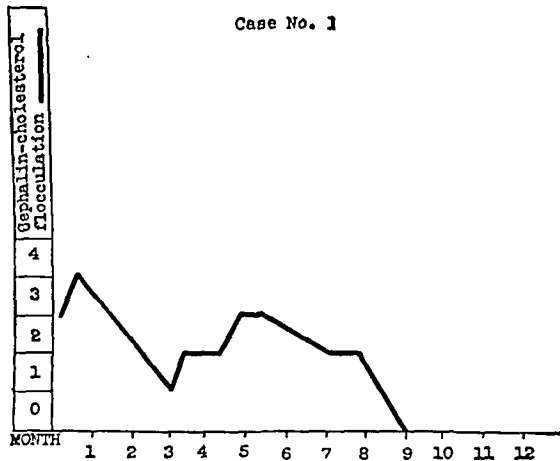


FIG. 2. Cephalin-cholesterol-flocculation test values (forty-eight hours) in Case 1 over a nine-month period following injury.

incisional hernia through an abdominal defect which extended beneath the twice repaired transverse incision of the initial operation. A meticulous repair occupying some two and one-half hours of operating time was done without any ill effects whatsoever and with an extremely smooth post-operative course. At no time did signs of hepatic insufficiency appear. Since June, 1948, the patient has been back at his old job as a welder doing a daily eight-hour stint of heavy work without undue fatigue or disability. One and one-half years after the repair of the incisional hernia the abdominal wall was very strong and well healed without any evidence of recurrence of the hernia or of any incisional weakness. (Figs. 3 and 4.)

**CASE II.** H. M., a sixteen year old white boy, was admitted to the surgical service of the Louisville General Hospital at 1:30 P.M., June 10, 1948. He had been injured when a jeep in which he was riding as a front seat passenger crashed under the rear end of a parked truck. The jeep's windshield was driven down pinning the patient against the seat. The impact of the windshield was against the lower thoracic cage of the patient.

The boy was unconscious on admission. Blood pressure was 70/30, pulse 140 and respiration 24 per minute. The scalp showed no external evidence of injury. The auditory canals were clear and the drums were normal. The pupils were dilated, the right greater than the left, but both reacted to light. At first there was deviation of the eyes to the left but this was soon replaced by gross nystagmus. There was ecchymosis of the left para-orbital

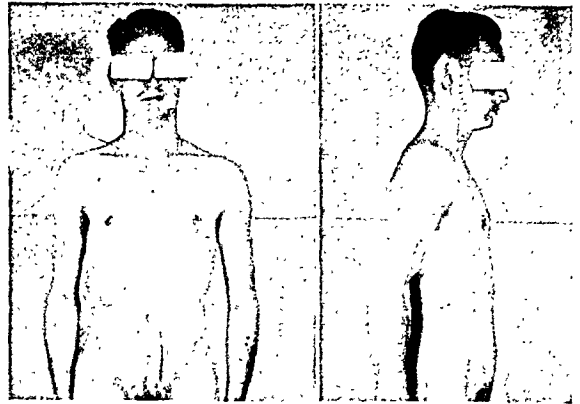


FIG. 3. Patient two years after injury. Case 1.

FIG. 4. Side view patient two years after injury. Case 1.

region, with edema of the left eyelid. There was an extensive area of contusion over the sixth, seventh and eighth rib on the right side with a depression in the mid-clavicular line at the seventh right rib. Crepitation was present over this area. The heart sounds were faint but otherwise normal. Abdominal examination revealed splinting of the right upper abdominal quadrant. Rectal examination was negative. There were no injuries to the extremities and the reflexes were normal.

It was believed that the patient had cerebral concussion, fractures of the sixth, seventh and eighth ribs and possibly rupture of the liver. The red blood count on admission was 4,150,000, hemoglobin 12 Gm. and the white blood count 26,500. Plasma was administered to maintain blood pressure while typing and cross matching were being done. Repeated red blood count one hour after admission was 2,510,000. Red blood cells and an abdominal paracentesis in the right upper quadrant revealed fresh blood. A transfusion of whole blood was started and the patient was removed to the operating room for an exploratory laparotomy. Blood pressure was then 130/55 and pulse 110.

The abdomen was opened through a transverse upper abdominal incision. The abdominal cavity was filled with blood. This was removed by suction into an autotransfusion set and 1,500 cc. of the patient's blood were given back to him during the operative procedure. There was an extensive laceration in the right lobe of the liver from the peritoneal reflection over the mid-portion of the dome of the right lobe to the under surface of the liver. The laceration was about 5 inches deep. It appeared that the right lobe of the liver had been split in half. There was active hemorrhage from the wound which was controlled by packing with large abdominal pads while the abdomen was explored. No other intra-abdominal disorder was found. Compressed sheets of dry gelatin foam (gelfoam) were then placed in the liver laceration

and the liver was held together for ten minutes. The laceration was then observed for ten minutes while blood replacement continued and the blood pressure was maintained at a satisfactory level. No further bleeding was noted and the abdomen was closed in layers with interrupted silk sutures. The abdominal cavity was drained through a stab wound through which Penrose drains were placed to the pouch of Morrison over the dome of the liver and along the right lumbar gutter.

For the first eight postoperative days the patient did well. Vitamin K was given in 40 mg. doses daily; penicillin, 60,000 units, was given every three hours and streptomycin, 1 Gm. daily, was started on the tenth day. Choline chloride, 4 Gm., and methionine, 4 Gm. daily, were also given. Sodium bicarbonate was given to alkalinize the urine and to protect the kidneys against damage from the multiple transfusions. On the sixth day the red count and hemoglobin had dropped and the patient was given a transfusion. Clinically, he seemed much improved. Fluid developed in the right pleural space and was removed by thoracentesis on the eighth and tenth days. The prothrombin time remained within normal limits. On the eleventh day following a blood transfusion the red count was 4,200,000, with a hemoglobin of 10 Gm. During the next forty-eight hours the abdomen gradually became distended and on the thirteenth day the patient's condition changed rather rapidly. He went into shock and it was obvious that there was intra-abdominal hemorrhage. A transfusion was started by ankle vein and the patient was moved to the operating room. Blood was also transfused in an arm vein so that blood replacement could be rapid to control blood loss. To obtain adequate exposure of the dome of the liver the abdomen was opened through a right thoraco-abdominal incision. Of the dark clotted and unclotted blood, 1,500 to 2,000 cc. were removed from the abdominal cavity. There was a wide, gaping wound of the right lobe of the liver which contained necrotic, autolyzed liver. This was removed while rapid blood replacement maintained an adequate blood pressure. No bleeding could be found in the liver wound. The abdominal cavity was again explored and still no other source of hemorrhage could be found. The thoraco-abdominal wound was closed with drainage.

In the next twenty-four-hour period the patient was given 5,300 cc. of blood by continuous transfusion. The abdomen again became distended and paracentesis was necessary on two occasions, removing 1,400 and 1,000 cc. of bloody fluid. At times there was bright red blood on the wound dressing. The patient continued to bleed and on the twenty-first day, eight days after the second operation, he again went into severe shock and appeared to be dying. Blood was rapidly syringed into an ankle vein and the blood pressure was elevated to

systolic 122, diastolic 68. It was believed that the only chance for survival was to find the source of the bleeding. He was taken to the operating room with blood transfusion as before and the thoraco-abdominal wound was reopened. From the large defect in the liver, necrotic liver was again removed

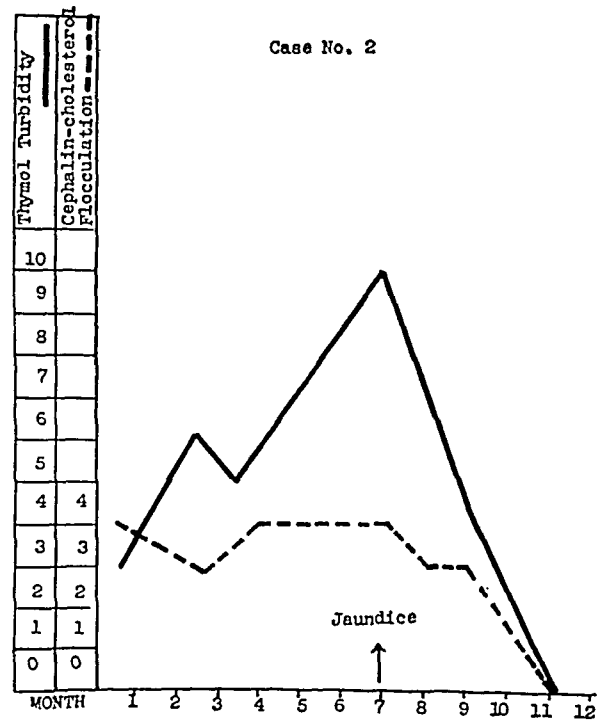


FIG. 5. Thymol turbidity and cephalin-cholesterol-flocculation test values (forty-eight hours) in Case 11 over an eleven-month period following injury.

in great quantity. The blood pressure had been elevated by rapid transfusion of 2,000 cc. of whole blood (blood pressure was 120/70 to 120/80) adequate to produce bleeding but no bleeding point could be demonstrated. The abdomen was carefully explored. It was thought that there might be bleeding from the splenic pedicle so the spleen was removed. The wound was closed by through-and-through sutures with drainage. For the next eight days the patient was kept alive by a continuous blood transfusion, receiving a total of 10,750 cc. of blood. The abdomen remained distended and seven days after the third operation the red blood count was 5,780,000 and hemoglobin 16 Gm. The patient then began to improve and to maintain a satisfactory blood picture although on the thirty-second day he became edematous and developed fluid in the left chest. Plasma protein was low at 5.9 mg. per cent. On the thirty-fourth day a large amount of bright red blood was observed on the wound dressing and the patient went into shock. Blood was rapidly syringed into an ankle vein and a continuous transfusion was kept running for the next forty-eight hours. After this episode there was apparently no liver hemor-

rhage of any consequence. The patient began to improve on about the thirty-eighth day, gaining weight and strength gradually. The cephalin-cholesterol flocculation and thymol turbidity tests indicated severe liver damage. (Figs. 5 and 6.)

The patient was discharged from the hospital on the 112th day following injury. Two months after

COMMENT

The efficacy of a non-suture technic of liver repair using sheets of oxidized cellulose (oxycel) or of gelatin foam (gelfoam) and manual compression was demonstrably impressive at the operating table in both cases.

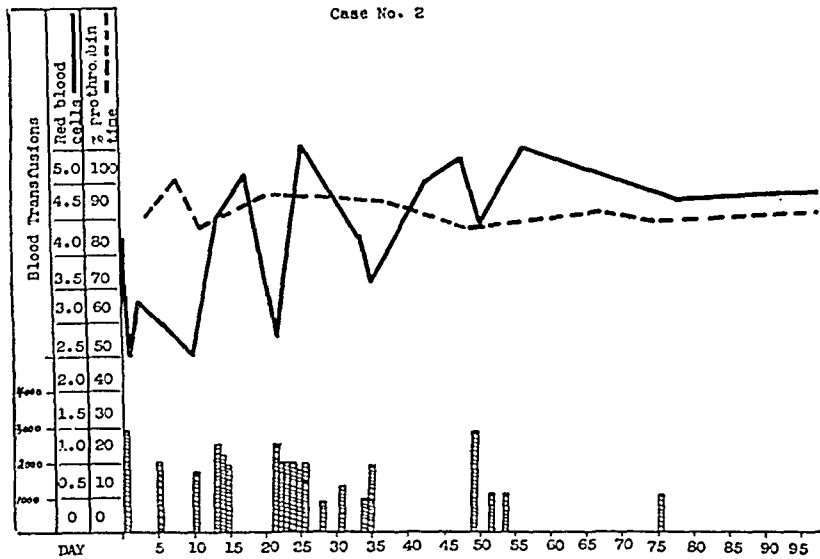


FIG. 6. Red blood count and prothrombin levels in Case 11; whole blood transfusions indicated by cross-matched columns.

discharge he developed jaundice, anorexia and vomiting and was readmitted to the hospital. On the medical service a diagnosis of homologous serum jaundice was made. Liver studies indicated no improvement in liver function; however, the

In Case 1 the indications for and extent of débridement necessary were clear due to the presence of a large mass of almost completely amputated liver tissue plus extensive pulping of liver tissue which literally demanded removal. Because of the complete débridement of as much non-viable hepatic tissue as could be determined at the initial operation in this case, sequestration was minimal and secondary hemorrhage did not occur even though a massive wound disruption and extensive evisceration occurred on the third postoperative day.

In Case 11 repeated secondary hemorrhage was thought due to continuing sequestration of liver tissue resulting from the initial devitalizing contusion. In this case, as in similar cases in which a single cleft in the liver exists or presents without evidence of comminution or gross pulping, the indications and the necessity for operative débridement of liver tissue were not as clear cut.

It is also important to note that in the face of extensive hepatocellular damage indicated by the cephalin-cholesterol flocculation and thymol turbidity tests neither of these patients developed signs of the dreaded "hepatorenal syndrome." Also interesting is the fact that

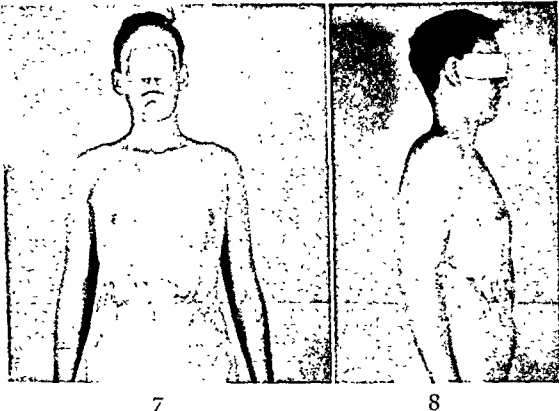


FIG. 7. Patient one year after injury. Case 11  
FIG. 8. Side view patient one year after injury. Case 11.

prothrombin time was 88 per cent of normal. This patient remained in the hospital for the next four months and liver function studies showed gradual improvement, returning to normal eleven months after the injury. He regained his normal weight and strength. (Figs. 7 and 8.)

normal or nearly normal prothrombin values were maintained in both cases without difficulty by large doses of synthetic vitamin K administered parenterally. This would seem to indicate a degree of hepatic reserve apparently belied by the other laboratory tests of hepatic function.<sup>25</sup>

The value of the thoracico-abdominal approach to lacerations extending over the dome of the liver, said to be the most frequent site of severe lacerations,<sup>2</sup> was well demonstrated in Case II, a long-waisted, hyposthenic individual with a high diaphragmatic vault. The use of autotransfusion in Case II without unfavorable reaction is to be noted.<sup>24</sup>

#### CONCLUSIONS

1. Massive hepatic rupture of the closed type is rare in civilian hospital practice and the hospital mortality in such cases is excessively high.

2. In extensively damaged livers suture repair is inefficient and control of hemorrhage difficult or impossible. As a consequence, the débridement of devitalized liver tissue is neglected entirely or inadequately performed.

3. Failure to débride damaged liver tissue adequately usually leads to autolysis and sequestration of hepatic tissue, secondary hemorrhage, sepsis, hepatorenal syndrome and death.

4. At the present stage of development of surgical technic improvement in the surgical management of hepatic rupture has been thwarted mainly by lack of an adequate technic for the control of hemorrhage from damaged hepatic tissue.

5. A non-suture technic employing gelatin sponge (gelfoam) or oxidized cellulose (oxycel) has been described which permitted fairly extensive débridement of damaged liver in one case and gave highly satisfactory immediate and late results in two cases.

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# EXTENSIVE RESECTION OF THE SMALL INTESTINE\*

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**O**CCASIONALLY a severe pathologic condition in the abdomen requires the removal of an extensive amount of small intestine. The problem may arise in emergency cases such as abdominal injury, volvulus and mesenteric thrombosis. It also may arise in patients with regional enteritis who have had repeated resections of small intestine and other chronic conditions. The extent of the resection is usually dictated by the pathologic condition encountered yet an understanding of the consequences of extensive resection is of great value to the surgeon at the time of operation as well as the internist who follows-up the patient later. It is hoped that our experience with two such cases and a third less extensive case in the past year and a half will be of interest to others.

## CASE REPORTS

**CASE 1.** S. E. S., No. 265-750, a forty year old colored orderly at University Hospitals was seized with severe, crampy epigastric pain August 20, 1947. He had no nausea or vomiting and his bowel movements had been normal. It was a very warm day and the patient had been perspiring profusely while stacking mattresses. The patient had had two previous abdominal operations, namely, plication of a perforated duodenal ulcer eight years previously and a subtotal gastric resection for ulcer six months previously at another hospital. The first examination was one and a half hours after onset of pain.

On examination his temperature was 36.8°C., pulse 76, respiration 20 and blood pressure 118/68. He was a thin colored man soaked with perspiration complaining of epigastric pain. There was slight epigastric tenderness but no muscle spasm. Liver dullness was preserved; there was a well healed right upper rectus scar.

The patient was admitted to the hospital because of x-ray findings. Scout films of the abdomen showed no free gas under the diaphragm and no dilated loops of bowel. There was a small amount of gas in right abdomen thought to be in the cecum.

Normal saline was administered intravenously with very little change in pain. Six hours later the

patient's temperature was 37.4°C., pulse 80, blood pressure 120/60 and white blood cells 13,700. At this time there was marked tenderness and muscle spasm in the right lower quadrant of the abdomen and also tenderness by rectal examination. Urinalysis was normal. In view of the signs of peritoneal irritation the patient was taken to surgery.

The patient was operated upon August 20, 1947. When the abdomen was opened through a right rectus incision, a foul odor and black loops of bowel were noted. It first appeared that the entire small intestine was gangrenous although not particularly dilated. When the gangrenous loops were eviscerated, a dense fibrous band  $\frac{1}{2}$  cm. in diameter was discovered running from the jejunum about 20 inches below the previous anastomosis with the stomach to the transverse colon. It was apparent on division of this band that almost the entire small intestine had herniated around it in a clockwise manner through 180 degrees with complete occlusion of the blood supply. There was complete gangrene of the bowel from a level 20 to 24 inches below the anastomosis with the stomach to a point 4 inches proximal to the ileocecal valve. Resection was carried out preserving all possible viable bowel and an end-to-end anastomosis was made just proximal to the cecum. The abdomen seemed nearly empty after resection, the loop being just of sufficient length to make the anastomosis.

During the course of the operation the blood pressure dropped to 80 mm. of mercury but with 1000 cc. of plasma and 500 cc. of whole blood the vital signs were surprisingly good at the close of the procedure.

The pathologic report on the surgical specimen was necrosis of jejunum and ileum, the segment measuring 16.6 feet (510 cm.).

The patient had a rather stormy postoperative course for eighteen days. Then, following drainage of a deep wound abscess, his temperature returned to normal. During the immediate postoperative period the patient was maintained on parental glucose, saline and amigen with added vitamins. A Levine tube was used intermittently during the first week. Liquid feedings were started in small amounts on the fourth postoperative day and were gradually increased. A high caloric, high protein and low fat diet was begun on the eight postoperative day. Protein hydrolysate was also given after

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meals. With the onset of oral feedings the patient developed four to seven liquid stools per day and noted the urge to defecate shortly after eating. Bismuth and paregoric drachms 11, A.C. seemed to be of slight benefit. Preoperatively the patient's usual weight was 58 Kg. On the nineteenth postoperative

was 40 Kg. (88 pounds) and he appeared extremely emaciated. He had learned to control his diarrhea partially by frequent small feedings and withholding fluids. He was still having two to four liquid stools per day. The patient became anemic and bedridden due to extreme weakness, developed

TABLE I  
LABORATORY FINDINGS, CASE I  
(SUBTOTAL GASTRIC RESECTION WITH THIRTY INCHES SMALL BOWEL REMAINING)

Date	Hemo- globin Per cent	Red Blood Cells	White Blood Cells	Urine	Plasma Pro- tein	A/G Ratio	P	Blood Ca.	Blood Sugar	Blood Urea Ni- tro- gen	Pro- throm- bin Per cent	Cho- les- terol	V.K. Mg.	Folic Acid Mg. qd.	Weight kg.	Stools
8/20/47	Operation	.....	.....	N	...	...	...	...	..	23.3	..	..	....	..	58	
8/25/47	76	4.2	.....	..	...	...	...	...	..	16.5	..	..	....	..	....	4-7
9/19/47	Discharge	.....	.....	..	...	...	...	...	..	...	..	..	....	..	47.2	2-4
10/9/47	75	3.8	9,900	N	7.4	1.2	4.2	9.1	..	6	..	..	....	..	44.6	4-10
11/5/47	60	3.6	.....	..	6.2	1.1	3.1	8.5	..	...	..	..	....	30	42	2
11/10/47	..	.....	.....	..	...	...	...	...	..	7.5	..	..	....	↓	..	..
11/14/47	78	3.51	.....	..	...	...	3.7	9.3	59	....	18	..	20 t.i.d.	..	44.6	1
11/20/47	..	.....	.....	..	...	...	...	...	..	....	..	..	↓	30	..	..
11/29/47	78	4.6	.....	..	...	...	...	...	..	...	62	..	..	..	43.3	2
12/2/47	75	.....	.....	..	...	...	...	...	..	...	..	82	..	..	42.9	1
12/4/47	..	.....	.....	..	...	...	...	...	..	...	..	..	..	..	43.7	2
12/8/47	..	.....	.....	..	...	...	...	...	..	...	65	..	↓	..	41.8	1
12/13/47	..	.....	.....	..	5.7	...	...	...	..	...	..	..	..	..	42.6	4
12/20/47	Discharge	.....	.....	..	...	...	...	...	..	...	..	..	..	..	43	..
12/27/47	62	3.1	10,000	N	...	...	...	...	..	...	40	..	..	..	....	1-2
1/6/48	60	3.5	.....	..	5.1	.9	...	...	..	...	..	..	..	..	..	..
4/12/48	61	3.4	9,400	A+	4.7	...	...	6.9	..	....	..	..	..	..	40	2-4
4/21/48	52	2.4	6,400	N	...	...	...	...	..	...	..	..	..	..	..	..
4/28/48	58	3.0	.....	N	...	...	...	...	..	...	..	..	..	..	..	..
5/14/48	60	3.5	6,700	..	3.4	.9	...	...	..	4.5	..	..	..	..	..	..
5/15/48	Expired	.....	.....	..	...	...	...	...	..	...	..	..	..	..	..	..

day he weighed 47.2 Kg. At the time of discharge September 19, 1947 (twenty-ninth postoperative day), he was having two to four semi-formed stools a day and seemed to be reaching an equilibrium.

However, the patient gradually lost weight on a high caloric, low fat diet and was readmitted to the Medical Service on October 9, 1947, three weeks later, because of four to ten liquid stools per day which were light yellow, foul smelling and foamy. His weight was 44.6 Kg. (98 pounds). He was unable to eat a full meal without the urge to defecate. However, smaller amounts of food such as a glass of milk could be taken without difficulty. His appetite was very good in spite of which he had become weak and malnourished.

The patient was kept under observation in the hospital until December 20, 1947. During this time studies were carried out with various diets, aluminum hydroxide, extract of belladonna and folic acid. Gradually the patient continued to lose weight and at the time of discharge four months following the operation he weighed 43 Kg. (95 pounds).

The patient was readmitted April 12, 1948. He complained of weakness, weight loss, inability to climb stairs and loss of libido. He was also having some pain in the left leg due to phlebitis. His weight

edema of legs and face and fluid in his chest and finally died May 15, 1948, eight months and twenty-five days following operation. Autopsy was not obtained.

The laboratory findings (Table 1) were as follows: oral glucose tolerance; fasting 55, one-half hour, 83; one hour, 92; two hours, 77; three hours, 80 and four hours, 64 mg. per cent with no sugar in urine. The Wassermann test was negative.

*Comments.* This patient had 24 to 30 inches of small bowel between the remaining portion of his stomach and his ileocecal valve. Approximately 12 per cent of his small bowel remained. The previous subtotal gastric resection had short circuited his duodenum and diminished the digestive action of his stomach. Food passed into the cecum a few minutes after being taken by mouth. Because of this the patient had diarrhea and severe weight loss of 18 Kg. and died literally of starvation, not being able to absorb adequate nourishment from the food taken by mouth.

Before death a rather marked hypochromic anemia developed, the plasma proteins fell to 3.4 Gm. per 100 cc. The blood urea nitrogen,

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blood calcium and plasma cholesterol were all diminished. The glucose tolerance curve was very flat. The patient developed hypoprotrombinemia which responded to vitamin K administration by mouth. Various drugs to slow the passage time through the bowel were

supervision. In order to produce variety and hence willingness on the part of the patient to take the full diet, three different food schedules for each study period were composed and administered on successive days. These schedules were as nearly identical as possible in protein,

TABLE II  
STOOL ANALYSES CASE I WITH VARIOUS DIETS

Study Period	Diet (Three-day Total)			Stool Analysis (three-day collection)					
				Total Solid Gm.	Total Fat Gm.	Fat, Per cent Total Fecal Solid	Fat, Per cent Ingested Fat	Nitrogen Gm.	Nitrogen, Per cent Ingested Nitrogen
I 12-12 to 12-14 inclusive	Pro- teins 57 (171)	Carbo- hydrates 211 (633)	Fat 104 (312)	267	186	70	59	12.3	45
II 1-1 to 1-3 inclusive	Pro- teins 58 (174)	Carbo- hydrates 208 (624)	Fat 209 (627)	460	297	65	47	16.9	61
III 1-6 to 1-8 inclusive	Pro- teins 59 (177)	Carbo- hydrates 406 (1,218)	Fat 107 (321)	200	91	45	28	8.2	29

not adequate. The patient tolerated a low fat, high carbohydrate diet better than others. Although the blood calcium fell to 6.9 mg. per cent, tetany did not develop.

*Absorption Studies Case 1.* The results of fecal fat and nitrogen studies, carried out as described hereafter, are shown in Table II. Diets for individual study periods of five days were maintained constant. The first two days of each period stool specimens were discarded, the collections for analysis being begun at 8 A.M. on the third day. An attempt to mark the stools with charcoal was found impracticable because of their semi-liquid consistency. Collections were made in glass containers for seventy-two hours and immediately thereafter analyzed or refrigerated. A homogenous mixture of the seventy-two-hour specimen was prepared by suitable stirring and aliquots were examined for total solids, total fat and nitrogen. Solids were determined by drying in an oven for forty-eight hours. Total fat was performed by a modified method of Fowweather and nitrogen by the Kjeldahl method. Diets utilized in the study periods were carefully weighed and were consumed under constant

carbohydrate and fat content as well as in mineral and water content. Diets were administered in six daily feedings all of which were as nearly equal as possible. Care was taken to see that the patient consumed all food placed before him. Extradietary water was maintained at as constant a figure as possible.

As can be seen from Table II the inability of this patient to metabolize normally both fat and protein is obvious. The ratio of total fat in the stools to both total solids and ingested fat is well above accepted normals. The increased loss in nitrogen is likewise evident. A comparison between study period I (dietary fat 312 Gm.) and study period II (dietary fat 627 Gm.) is of some interest. During the high fat regimen there was a substantial increase in total fecal solids, total fecal fat and to a somewhat less extent an increase in fecal nitrogen. Since ratios of fecal fat to the total fecal solids and ingested fat were not significantly changed, it seems that the principle effect of the high fat diet is concerned with increasing the bulk of the stool. Wolaeger et al.<sup>1,2</sup> in a series of studies upon normal persons found that there was no significant difference in the total fecal solids

when a diet of high fat (208 Gm.) and a diet of moderate fat (101 Gm.) content were administered. In these normal persons the amount of fecal fat as well as its ratio to total fecal solids was increased with the high fat intake. Interestingly, the fat content of the diets em-

TABLE III  
CALORIC INTAKE AND LOSS CASE I WITH VARIOUS DIETS

Observation Period			Caloric Intake	Caloric Loss (Stools)	Available Calories
Proteins 171	I Carbo- hydrates	Fat	6,024	1,982	4,042
	633	312			
Proteins 174	II Carbo- hydrates	Fat	8,835	3,095	4,740
	624	627			
Proteins 174	III Carbo- hydrates	Fat	8,457	870	7,587
	1,218	321			

ployed by these authors were roughly similar to that used in this patient in periods I and II. The difference between those normal people and this patient, therefore, seems in the latter instance to be the volume of stool passed under the influence of changes in dietary fat.

Observation period III was characterized by a diet similar in protein and fat content to the control (period I) but with a doubled carbohydrate content. As may be seen there was a lowering of fecal fat both in actual volume and in its relation to total fecal solids and ingested fat. There was an accompanying slight reduction in nitrogen loss. Explanation for these results is not clear and will require further amplification and clarification. Table III shows the caloric balance with respect to fecal loss for the three periods of observation. These figures are based upon the supposition that nitrogen loss in the stools is in the form of protein and that carbohydrate loss is negligible. Computations on this basis, therefore, represent the maximum in available calories. In observation periods I and II these obviously were deficient. The balance in period III more nearly approaches normal caloric requirements and would suggest that a diet of this general character might be the most advantageous in a patient of this sort.

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CASE II. J. H. W., No. 271-092, a twenty-six year old white man, entered University Hospitals February 22, 1948, with abdominal cramps and vomiting of four days' duration. Seven previous operations had been performed elsewhere with three bowel resections for regional enteritis during the previous ten years. The last resection had been four years previously. The return of abdominal pain and diarrhea had occurred during the two months prior to admission with a weight loss of 20 pounds.

On examination the patient's temperature was 37.5°C., pulse 96, respiration 22 and blood pressure 114/54. His weight was 54.5 Kg. (120 pounds). He was thin and pale. His abdomen showed numerous broad scars. Moderate abdominal distention and visible peristalsis were present with borborygmi.

X-ray examination showed dilated small bowel loops. A Miller-Abbott tube met obstruction in the jejunum.

When the patient was operated upon March 4, 1948, extensive adhesions and a matted small bowel with greatly thickened wall were found. Obstruction was present in several places. Resection of an additional 115 cm. (3.8 feet) of jejunum was necessary and a jejuno-colic anastomosis was carried out (18 inches jejunum remained later shown at autopsy).

The patient made a good recovery. There was diarrhea of five to thirteen liquid bowel movements per day with onset of feeding. There was gradual weight loss only slightly influenced by a high caloric, low fat diet, hydrolysed proteins and paregoric. At the patient's own request he was discharged April 3, 1948 (thirtieth postoperative day), having an average of five liquid bowel movements per day and weighing 44 Kg. (96.8 pounds).

The patient was readmitted to the Medical Service June 21, 1948, complaining of left flank pain, bloody urine, weakness and frequent bowel movements although he ate mostly starchy foods. He weighed 38.2 Kg., an additional loss of 6 Kg. during the two and a half months he was out of the hospital. After many cystoscopies, a left ureteral stone was removed surgically August 30, 1948. In spite of all dietary attempts and Tween-80,\* as suggested by Jones et al.,<sup>3</sup> the patient gradually continued to lose strength and weight until he looked like a skin-covered skeleton. His last weight in December, 1948, was 33.7 Kg. He became bed-ridden about November 1st. His morale became very bad and he finally expired December 15, 1948, after an overdose of barbiturates which he had accumulated in his bed stand. Autopsy showed only 18 inches of jejunum remaining which was somewhat dilated but otherwise normal. The body was extremely emaciated and there was active tuberculosis without cavitation in the left lung.

\* Polyoxyethylene sorbitan monooleate kindly supplied by Abbott Laboratories.

The laboratory findings (Table IV) were as follows: tuberculin 1/10,000 positive; duodenal contents showed normal proteolytic activity; oral glucose tolerance; fasting 94, one hour, 125; two hours, 93; three hours, 82; four hours, 80, with no sugar in urine; intravenous glucose tolerance; fast-

The patient developed hypochromic anemia and diminution of plasma proteins. He did have urinary bleeding due to his ureteral stone but this was controlled by blood transfusions and ureterotomy three and a half months before death. The blood calcium dropped to 7.2 mg.

TABLE IV  
LABORATORY FINDINGS CASE II  
(EIGHTEEN INCHES JEJUNUM AND ELEVEN INCHES DUODENUM REMAINING)

Date	He- mo- globin Per cent	Red Blood Cells	White Blood Cells	Urine	Ser- um Pro- tein Gm.	A/G	Ser- um Ca. Mg.	p	Blood Sugar	Blood Urea Ni- trogen Mg.	Pro- throm- bin	Chlo- rides Mg. Per cent	MPT	Uric Acid Mg.	T-80 t.i.d.	Pan- cre- atic ex. b.i.d.	Weight kg.	Stools
2/22/48	95	4.7	6.8	N	6.4	...	...	...	...	10.5	...	571	neg.	...	...	...	54.5	
3/4/48	Resection small bowel																	
o.p.																		
3/16/48	80	4.05	...	N	...	...	...	...	94	...	82	...	...	...	...	...	47.3	12
4/3/48	Discharge																	
6/21/48	85	4.3	8.1	RBC	6.1	1.4	...	...	...	12	...	570	...	...	...	...	44	4
7/7/48	88	4.3	...	RBC	...	...	...	...	...	6.8	...	576	...	...	...	...	38.2	5
7/16/48	...	...	...	RBC	5.3	1.8	7.2	...	...	...	...	...	...	...	...	...	40.2	1
7/24/48	...	...	...	RBC	...	...	9.2	3.7	...	...	...	...	...	4	...	...	41.2	2
7/29/48	65	3.2	8.25	N	5.9	...	...	...	...	12	...	530	...	...	...	...	37.6	4
8/6/48	78	3.03	6.0	...	...	...	...	...	...	...	...	...	...	...	...	...	34.5	2
8/16/48	80	...	6.5	N	6.2	1.1	...	...	...	15.8	...	...	...	...	...	...	35	1
8/24/48	85	...	...	...	...	...	...	...	...	9.0	...	558	...	...	...	...	34.8	1
8/30/48	Left ureterotomy																	
9/2/48	...	...	...	WBC	...	...	...	...	...	7.5	...	...	...	...	...	...	31.7	3
9/7/48	70	3.81	6.8	WBC	...	...	...	...	...	...	...	...	...	...	...	...	31.6	5
9/9/48	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10/12/48	75	2.78	3.8	WBC	...	...	...	...	...	...	...	...	...	...	3.3	2.5	31.2	2
11/15/48	53	2.24	3.8	N	5.3	1.7	...	...	...	...	...	607	...	...	...	...	33.2	2
12/10/48	50	2.4	3.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12/15/48	Patient expired																	

ing 90, one hour, 161, with 2+ sugar in urine; two hours, 94; three hours, 66 and four hours, 65 mg. per cent. Blood smear taken on June 21st showed anisocytosis, poikilocytosis and hypochromia; platelets were increased. The differential count was as follows: segmented 51, unsegmented 13, lymphocytes 11, monocytes 9, eosinophiles 0, basophiles 1 and basket 15. On March 26, 1948, carmine dye passed per rectum two and a half hours after ingestion. Three day stool specimen collected September 10th showed the following: total solids 199 Gm., total fat 113 Gm. (57 per cent) and total nitrogen 11.4 Gm. (5.75 per cent).

**Comments.** This twenty-six year old man had all but 18 inches of his jejunum removed in successive stages due to regional enteritis. The duodenum was 11 inches long giving a total of 29 inches of small bowel between the stomach and colon. With this he maintained life for nine months. Similar to Case I there was diarrhea and extreme loss of weight (21 Kg.) and strength before death. Although the diarrhea was controlled to some extent by diet and drugs, the stools remained quite bulky and contained a large amount of fat (57 per cent).

and this rose to 9.2 with the administration of calcium gluconate orally.

**CASE III.** E. J. G., No. 186-016, a thirty-two year old colored man, was readmitted to University Hospitals May 12, 1948, two hours after discharge, because of epigastric pain, vomiting and diarrhea. He had spent the previous two weeks in the hospital because of pain in the left chest and a pericardial friction rub which had been diagnosed acute pericarditis subsided with bed rest.

On examination his temperature was 36.9°C., pulse 88, respiration 20 and blood pressure 126/88. His weight was 75 Kg. (166 pounds). There was tenderness in the right upper quadrant of the abdomen with some involuntary muscle spasm. The lower abdomen was completely normal. White blood cells were 9,000.

The pain continued in the abdomen and became more severe. On May 14, 1948, his temperature was 39.5°C., pulse 90; respiration 24, blood pressure 110/70 and white blood cells 18,700. There was diffuse tenderness and spasm most marked in the lower abdomen. The diagnosis was acute peritonitis.

The operative findings on May 14, 1948, were as follows: gangrene of terminal ileum, cecum and

TABLE V  
LABORATORY FINDINGS CASE III  
(RESECTION 5.5 FEET TERMINAL ILEUM AND RIGHT HALF OF COLON)

Date	Hemo- globin Per cent	Red Blood Cells	White Blood Cells	Urine	Serum Pro- tein Gm.	A/G Ratio	P	Ca.	Blood Urea Nitro- gen Mg.	Cholesterol	Folic Acid t.i.d.	T-80 Gm. t.i.d.	Weight Kg.	Stools Per Day
4/27/48	90	4.84	8,300	N	...	...	...	...	9	...	....	...	75	1
5/12/48														
5/14/48 o.p.														
5/15/48	85	4.84												
5/17/48	85	4.7												
5/18/48														
5/19/48	..	....	....	..	...	...	...	...	...	...	....	....	....	3
5/25/48	75	4.38	....	..	...	...	...	...	...	...	....	....	....	4
5/28/48	73	...	....	..	6.6	1.4	...	...	...	...	....	....	61.3	8
7/27/48	80	4.4	6,100	..	6.3	1.6	...	...	7.5	...	....	....	59.6	3
7/30/48	..	....	....	..	...	...	...	...	...	97	....	....	....	1
8/12/48	..	....	....	N	...	...	...	...	...	...	.015	....	....	2
8/16/48	..	4.07	4,100	..	7.3	1.2	...	...	...	...	....	....	....	2
8/20/48	66	3.71	...	N	...	...	...	...	...	...	....	....	60.4	2
8/25/48	..	....	....	..	...	...	...	...	...	...	....	4.5	60.6	1
8/26/48	..	....	....	..	6.5	1.03	3.6	9.5	...	69	....	↓	...	1
9/3/48	..	....	....	..	6.8	1.4	...	...	...	109	....	...	...	1
9/12/48	..	....	....	N	...	...	...	...	...	...	....	9.9	...	
9/17/48	70	....	3,959	..	6.5	1.5	...	...	...	110	....	...	59.2	1
9/28/48	70	4.08	3,700	..	...	...	...	...	...	121	....	↓	58.8	1
10/2/48	Discharge	....	....	..	...	...	...	...	...	...	....	↓	...	

TABLE VI  
STOOL ANALYSES CASE III WITH FOLIC ACID AND TWEEN-80

Study Period	Diet			Medication	Stool Analysis (3 day collection)					
	Three-day Total				Total Solids Gm.	Total Fat Gm.	Fat, Per cent of Total Fecal Solids	Fat, Per cent Ingested Fat	Nitrogen Gm.	Nitrogen, Per cent Ingested N.
	P	C	F							
I 8-8 to 8-10 inclusive	255	867	225	None	227	128	56	59		
II 8-16 to 8-18 inclusive	259	861	228	Folic acid .015 Gm. q.d.	174	100	58	44		
III 8-26 to 8-28	257	842	216	Folic acid .015 Gm. q.d. Tween-80 4.5 Gm. q.d.	222	130	60	60		
IV 8-31 to 9-2 inclusive	263	893	229	Folic acid .015 Gm. q.d. Tween-80 4.5 Gm. q.d.	200	104	50	45		
V 9-24 to 9-26 inclusive	247	803	225	Folic acid .015 Gm. q.d. Tween-80 9.9 Gm. q.d.	236	119	51	53	9.9	25

ascending colon due to mesenteric thrombosis. One hundred sixty-five cm. (5.5 feet) terminal ileum plus right half of colon removed and bowel anastomosed, upper ileum to transverse colon.

The patient made a satisfactory postoperative recovery. Anticoagulants were administered for ten days. Diarrhea consisting of four to eight liquid stools per day was partially controlled with high caloric, low residue diet and paregoric. The patient was discharged on his twenty-fourth postoperative day weighing 61.3 Kg. and having three to four loose stools per day.

The patient was readmitted July 27, 1948, to the Medical Service because of thrombophlebitis of the left leg. He also complained of three to five loose stools per day and weight loss. He was treated with bed rest, heparin and dicumarol with improvement of the thrombophlebitis. The patient was discharged October 2, 1948, weighing 58.8 Kg. and having one to two soft voluminous stools per day. He was reported to be getting along satisfactorily one year after operation.

The laboratory findings (Table v) were as follows: gastric analysis showed no free hydrochloric acid; duodenal contents showed normal pancreatic activity; oral glucose tolerance test September 28, 1949; fasting 86, one-half hour, 126; one hour, 124; two hours, 87; three hours, 85 and four hours, 73 mg. per cent. Intravenous glucose tolerance test September 18, 1948; fasting 74, one-half hour, 128 and one hour, 116 mg. per cent. Vitamin A tolerance test; fasting 1 unit; one hour, 1 unit. The blood Wassermann test was negative.

*Comments.* This thirty-two year old colored man is of particular interest because of rather severe digestive disturbances following resection of a relatively short segment of terminal ileum (5.5 feet) with the right half of the colon. Pancreatic enzymes in the duodenal secretions showed normal activity. The transit time of food was one hour from mouth to transverse colon. Diarrhea in this case was fairly well controlled by drugs and low fat, high carbohydrate diet. However, the patient lost 16 Kg. during the first five months after operation and developed a mild anemia and lowered blood cholesterol.

Metabolic studies on this patient are summarized in Table vi. Observation periods, methods of diet administration, stool collections and stool analyses were carried out as in Case 1. The diet was maintained constant throughout all five observation periods, the difference between the periods being only in the medication administered. Folic acid was given in one dose in the morning before the first feeding. In period III Tween-80 was adminis-

tered in three equally divided doses after morning, midday and evening feedings whereas in period IV it was given in the same fashion but before the same feedings. In period V Tween-80 was given in the same manner as in period IV except the amount was doubled. As may be seen there was no significant alteration in fat absorption when this patient was given folic acid alone or with Tween-80. Jones, Culver, Drummey and Ryan<sup>3</sup> administered Tween-80 to a selected group of patients showing defective fat absorption following subtotal gastrectomy and to persons with sprue, ileitis and pancreatic fibrosis. They were of the opinion that this material increased vitamin A absorption in these people. In further studies upon malnourished persons following subtotal gastrectomy they were of the additional opinion that Tween-80 lowered the total fecal fat and fecal percentage of ingested fat in these patients. It may be that the lack of effect of this substance in this patient is concerned with the reduction of absorptive area as a result of the bowel resection. Substantiating a lack of effect from Tween-80 in this patient was his failure to gain weight during its administration for one month. It is of interest to note that both in this patient and patient II there was a fall in the total leukocyte count during the administration of Tween-80.

#### HOW MUCH SMALL BOWEL MAY BE REMOVED

Senn in 1888 was of the opinion that one-third of the small intestine (200 cm. or 6½ feet) could be removed without serious nutritional disturbance to the individual. Haymond<sup>4</sup> in reviewing the literature in 1935 collected 257 cases in which 200 cm. or more small bowel was removed for various reasons. The over-all operative mortality was 33.5 per cent which he thought was probably not a true figure since unsuccessful cases tend not to be reported in the literature. Of the survivors 36.7 per cent were reported to have done well. Taking 657 cm. (21.9 feet) as the average length of the small bowel, there were eighty-six cases with good results in which the patient had an average of 47.2 per cent of the small intestine removed. There were twenty-one cases with fair results in which an average of 55.8 per cent was removed and fifteen cases with poor results in which an average of 52.9 per cent was removed. This author concluded that 50 per

cent removal of the small intestine constitutes the upper limit of safety.

Successful cases have been reported in the recent literature<sup>5-9</sup> in which the remaining segment of jejunum was  $3\frac{1}{2}$  feet or less in length. The patient studied by West<sup>7</sup> had repeated bouts of tetany due to low blood calcium. Further studies are reported on this case by Todd et al.<sup>10</sup> The other cases were apparently without significant digestive difficulties five to seven months after operation. Longer follow-up reports on these cases would be of interest.

Other recent cases of successful extensive resection of small intestine have been reported.<sup>11-20</sup> Washburn<sup>23</sup> reports the case of Jerauld and Washburn<sup>22</sup> in which the patient is alive and doing satisfactorily twenty-two years after removal of approximately two-thirds of the jejunum and ileum.

Jensenius<sup>21</sup> observed that resection of the distal two-thirds of the small bowel in fifteen dogs lead to death in an average of 144 days. Three of five animals with resection of the proximal two-thirds of the small intestine, on the other hand, were unaffected by the resection while the other two died 91 and 118 days later. Impairment of fat absorption, diarrhea and shortening of the transit time of bowel contents were much less marked in animals with the proximal portion of the small bowel removed than in animals with the distal portion of the small bowel resected. He concluded that resection of the jejunum caused less physiologic disturbance than resection of the ileum. This work throws an interesting light on the problem of small bowel resection in that not only the length of the resection is important but also the level of the resection.

In regard to our first and second cases reported herein these men each had approximately 88 per cent of their small bowel removed. They made a good postoperative recovery but died of inanition approximately nine months later. These patients each had the distal portions of their small bowel removed. Case II is of further interest in that prior to our resection he had six feet of small bowel (approximately 27 per cent) between pylorus and colon and had lived comfortably for four years until recurrence of regional enteritis occurred. He was able to live satisfactorily with slightly less than one-third of his small bowel but died of inanition when an additional 3.8 feet was

removed. It should be noted that this man's intestine had been removed in successive stages over a period of years.

Case III on the other hand demonstrates serious metabolic disturbance following removal of approximately 25 per cent of the small bowel along with the right colon.

It appears from our experience and from that of others in the literature that the response to resection of the small bowel is quite variable. Many factors such as health, age of the patient and health of the remaining segment of the intestine are important. It also appears that distal resections of the small bowel are less well tolerated than proximal resections.

It appears in general that resections of 30 to 50 per cent are usually well tolerated and also that many patients do satisfactorily with greater percentages removed.

#### SUMMARY

Two cases of extensive small bowel resection (approximately 88 per cent) are reported. These patients had severe diarrhea, excessive fat in the stools, weight loss and anemia and died of inanition approximately nine months after operation.

A third case is reported in which the patient had severe digestive disturbance following removal of 5.5 feet of terminal ileum (approximately 25 per cent of the small bowel) and the right colon for mesenteric thrombosis.

The effect of various drugs and diets determined by metabolic experiments are reported in two of the cases. Case I showed a diminution in stool volume and fat content with a high carbohydrate, low fat diet substantiating the idea that these patients do best with this type of diet. Folic acid and Tween-80 did not significantly alter the fat absorption in Case III.

#### CONCLUSIONS

The response of patients to removal of extensive amounts of small intestine is quite variable.

Although two of our patients died of inanition nine months after removal of approximately 88 per cent of the small bowel, one of these had lived comfortably for four years prior to our operation with approximately 73 per cent of his small intestine resected.

Appreciation is expressed to Dr. John H. Grindlay for making available to us the work



of Dr. Hans Jensenius and to Dr. J. Ross Wells for his early interest in this problem.

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# MANAGEMENT OF RUPTURE OF THE DUODENUM DUE TO VIOLENCE\*

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**R**UPTURE of the duodenum from non-penetrating violence creates a distinct diagnostic and clinical problem requiring considerable judgment for proper surgical management. The increasing number of injuries, particularly those resulting from automobile accidents, will unquestionably increase the frequency of these cases. A review of the literature<sup>1-28</sup> reveals that many reports have dealt with the subject of perforation of the gastrointestinal tract from both non-penetrating and penetrating injuries. From these clinical surveys one realizes that non-penetrating (subcutaneous) rupture of the intra-abdominal viscera occurs commonly and more frequently than most clinicians suspect. In a statistical analysis of reported cases up to 1935 Counseller and McCormack<sup>26</sup> found that 1,183 subcutaneous ruptures of the intestines occurred without evidence of penetrating injury to the abdominal cavity. In this group of patients there were 113 with subcutaneous ruptures of the duodenum, about 10 per cent of all gastrointestinal ruptures from non-penetrating injury. The majority of authors has pointed out the difficulty in obtaining an adequate history, particularly when these patients are in a state of severe peripheral circulatory collapse. Moreover, they have stressed the fact that there are no pathognomonic signs which indicate the diagnosis of traumatic rupture in any specific part of the gastrointestinal tract. All observers have agreed that complicating involvement of other intra-abdominal organs such as the liver, spleen, pancreas, kidneys and the bladder tends to confuse the clinical picture so that an accurate diagnostic approach cannot be outlined. Injury to other parts of the body, particularly to the head and chest as well as the thoracic and lumbar spines, may overshadow and minimize any abdominal disorder.

Specific papers dealing with the subject of

subcutaneous perforation of the duodenum have appeared sporadically over a period of many years. Continental observers have written about this lesion and in America numerous observers have recorded occasional cases with clinical observations and impressions.<sup>29-40</sup>

Almost nothing has been written during the past twenty years about rupture of the duodenum due to non-penetrating violence. Of interest is the fact that the mortality rate from such a rupture has been placed in the vicinity of 90 per cent. The purpose of this discussion is to review the types of rupture of the duodenum due to violence, to correlate the history and physical findings with roentgenographic evidence of perforation and to report four of our own cases. In two cases the diagnosis was made preoperatively while in the remaining two cases the diagnosis was established after complications suggested further study.

## GENERAL CONSIDERATIONS

Rupture of any part of the gastrointestinal tract, particularly the duodenum by action of blunt force with little or no injury to the abdominal wall, is one of the most interesting subjects in the whole field of traumatic surgery. Clinicians working in the field of trauma must be constantly aware of the possibility of subcutaneous rupture of the duodenum when attempting to evaluate intra-abdominal injury. On the other hand, to those who are not familiar with traumatology of this region the possibility of intraperitoneal or extraperitoneal rupture of the duodenum is usually not considered. In the presence of non-penetrating injury to the abdominal wall one should teach the danger of rupture to all fixed intra-abdominal organs, particularly the liver, spleen, kidneys and the fixed portions of the gastrointestinal tract.

*History.* The history of trauma to the abdomen by blunt force regardless of type should

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direct the attention of the clinician to the possibility of a fracture of the duodenum. The injury may result from the patient's having been crushed between heavy objects, struck on the abdominal wall by a blunt force, run over by some type of vehicle or having been kicked directly in the abdomen. Automobile accidents may predispose to this lesion because many drivers are prone to trauma of the anterior abdominal wall, particularly in the region of the epigastrium, when they are forcibly shoved forward against the steering wheel. If the injury has been confined to the abdominal wall, the patient should relate an accurate description of the accident. However, many patients have associated injuries such as trauma to the thorax or the head and their condition precludes an accurate history.

*Physical Findings.* Non-penetrating rupture of the duodenum affords the physical findings of spontaneous or penetrating rupture of any hollow viscus in the abdominal cavity. There is usually evidence of peritoneal irritation whether the rupture is intraperitoneal or extraperitoneal. Certain findings are suspicious even though not pathognomonic of this injury.

1. Pain is usually a characteristic feature of non-penetrating rupture of the duodenum. Pain, for the most part localized in the epigastric region, may oscillate between the right and left hypochondriac regions. In some instances pain is said to be intense, severe and located deep in the abdominal cavity. In other cases the pain may occur characteristically in the posterior region of the upper abdomen and localize over the upper lumbar vertebral region. In cases of intraperitoneal rupture of the duodenum pain may be diffuse over the entire abdomen because of a generalized peritonitis which is at first chemical and later bacterial. Conversely, extraperitoneal rupture of the duodenum may not reveal such diffuse pain because there is less intraperitoneal irritation. In such instances pain may be localized to the lower thoracic and upper lumbar regions posteriorly.

2. Abdominal rigidity, usually an indication of peritoneal irritation, is characteristic of rupture of the duodenum due to violence and the degree of rigidity found depends upon the time of examination after injury. In the intraperitoneal rupture one would expect greater rigidity of the anterior abdominal wall than in the extraperitoneal variety.

3. Localized tenderness may be found in the

epigastric region suggesting the possibility of injury to the stomach or duodenum. Persistence of localized tenderness is frequently helpful in directing the surgical approach when operation is contemplated.

4. Nausea and vomiting may be associated with traumatic rupture of the duodenum and the degree of either of these clinical features will depend upon many factors. Recently ingested food predisposes to nausea and vomiting; with large rents in the duodenum copious amounts of duodenal secretion promptly escape into the peritoneal cavity initiating reflex vomiting.

5. Hypoactive peristalsis or absence of peristalsis indicates peritoneal irritation and suggests peritonitis.

6. Obliteration of liver dullness suggests the presence of a rapidly produced pneumoperitoneum such as results only from a rupture of a hollow viscus. Pneumoperitoneum can be confirmed in a large percentage of cases roentgenographically. Intraperitoneal rupture of the duodenum due to trauma can explain the source of air. In extraperitoneal rupture of the duodenum the presence of air about the right kidney by roentgenographic evidence may be diagnostic of this condition as pointed out by Sperling and Rigler.<sup>39</sup>

7. Pain in the testicles may be a sign of irritation in the retroperitoneal tissues by involvement of their nerve supply. When this sign is observed in patients who have sustained non-penetrating injury to the anterior abdominal wall, the clinician should consider extraperitoneal rupture of the duodenum. The significance of this observation was discussed by Butler and Carlson.<sup>35</sup>

8. The presence of air or gas in the pelvic tissues may indicate a tear of a retroperitoneal hollow organ. The duodenum is the most important hollow viscus subject to rupture and capable of allowing escape of air to the pelvic tissues.<sup>35</sup>

9. The physical findings of an intraperitoneal or an extraperitoneal abscess may be a cardinal sign in cases in which non-penetrating rupture of the duodenum has occurred many hours or even days previous to the initial physical examination. In one of our patients a retroperitoneal abscess which had existed for many weeks presented in the right lower quadrant. When a history of severe trauma is elicited in the presence of an unexplained abscess, rupture of the duodenum should be considered.

In another of our cases the physical findings soon after an episode of trauma were prominent in the right lower quadrant and led to the diagnosis of appendicitis. Discoloration and edema of the peritoneum indicated inflammation in the retroperitoneal space. Exploration of this area revealed clear, watery fluid suggestive of high duodenal content.

The degree of peripheral circulatory collapse and the clinical observations of temperature, pulse, respirations and blood pressure will help considerably in the evaluation of the patient's condition at any given time. They are not particularly significant in establishing the diagnosis of traumatic rupture of the duodenum.

*Laboratory Findings.* Clinical laboratory determinations may help to eliminate certain conditions and to establish the correct diagnosis of traumatic rupture of the duodenum. Leukocytosis is usually found in these cases and it may vary between the limits of 10,000 to 40,000 white blood cells. A low or falling red blood count and hemoglobin determination may indicate the degree of bleeding from such a rupture of the duodenum.

Because of the location and intensity of the pain associated with all of the other physical findings which have been mentioned, the consideration of traumatic pancreatitis should justify the determination of blood serum amylase. In some instances the blood amylase may be elevated either in conjunction with a rupture of the duodenum or due to traumatic pancreatitis alone.

Roentgenograms of the gastrointestinal tract are much more significant than any other laboratory procedure available to us at the present time. We have not been reluctant to visualize the stomach and duodenum following the technic of Hampton. Either lipiodol or thin barium sulfate may be used. In intraperitoneal rupture of the duodenum a definite sinus may be visualized and the diagnosis in this location may be demonstrated clearly. In the case of extraperitoneal rupture of the duodenum the roentgenogram taken either in the oblique or lateral position may demonstrate a sinus leading from the duodenal lumen to the retroperitoneal space. As mentioned, preliminary films of the abdomen may demonstrate a pneumoperitoneum suggesting the possibility of a ruptured hollow viscus which could result from intraperitoneal rupture of the duodenum. As pointed out by Sperling and Rigler, collection of air about the right kidney usually

suggests extraperitoneal rupture of the duodenum. These differential features of the roentgenographic survey should help immeasurably in making a more positive diagnosis of non-penetrating traumatic rupture of the duodenum.

#### DIAGNOSIS

Diagnosis of rupture of the duodenum due to violence is not always easy to establish preoperatively. From reported cases in the literature the rupture in the duodenum is not always found at operation. Clinical evaluation of the nature, type, location, extent and severity of the injury should always predispose to the assumption that intra-abdominal viscera have been injured.

Fracture of the liver is not particularly frequent and usually the findings are limited early to pain, abdominal rigidity, evidences of peritoneal irritation and localized tenderness in the right upper quadrant. This is not always true because there have been large fractures of the liver in which hemorrhage and biliary secretions into the peritoneal cavity were profuse, creating generalized abdominal signs and symptoms.

Rupture of the spleen frequently points to findings in the left hypochondriac region. The characteristic features of a ruptured spleen are: hemoperitoneum with diminished peristalsis, mild abdominal distention, pain in the left hypochondrium, elevation of the left diaphragm, a dull percussion note over the splenic region, pain in the left supraclavicular region, and often shock disproportionate to the abdominal findings because of rapid blood loss. The classical cases of ruptured spleen are not particularly difficult to diagnose but there are many cases which do not fall into this group.

Acute traumatic pancreatitis can only be diagnosed positively on the basis of an elevated blood serum amylase. The signs and symptoms of epigastric pain, local tenderness in this region, nausea and vomiting, and a state of collapse out of proportion to the physical findings should always make one consider the possibility of traumatic pancreatitis. Because the pancreas lies in close proximity to the duodenum, a traumatic rupture of the latter can occur concomitantly with acute traumatic pancreatitis. In one of our cases this combination of associated injury was noted.

Acute appendicitis is another possible diagnosis which must be differentiated from

traumatic rupture of the duodenum. We have seen cases of acute appendicitis associated with trauma to the anterior abdominal wall. In intraperitoneal rupture of the duodenum, gastric, duodenal, biliary and pancreatic secretions traverse the peritoneal cavity by flowing inferiorly across the right gutter. This fact explains symptoms and signs localized to the right lower quadrant. This point was clearly demonstrated in one of our cases and an appendectomy was performed before the correct diagnosis was made.

Fractured kidney is not particularly difficult to differentiate from rupture of the duodenum. The presence of blood in the urine usually confirms this diagnosis. Physical findings referable to the kidneys will suggest the correct diagnosis.

Subcutaneous perforation of the jejunum and ileum, either alone or in conjunction with traumatic rupture of the duodenum, would be difficult to diagnose. Obviously such perforations would create peritoneal irritation and in most instances a pneumoperitoneum. The other characteristic findings of intraperitoneal involvement should be present and consideration of injury to these organs would indicate the necessity of doing an exploratory operative procedure.

There are other conditions associated with trauma to the abdominal wall which have not been mentioned in this differential diagnostic scheme but those mentioned are the most important. In summary it may be said that if the surgeon will keep in mind the possible injuries to the various intraabdominal organs, chiefly fractures of the viscera, the possibility of rupture of the duodenum due to violence will not escape his attention.

#### TREATMENT

*Preoperative.* Management of non-penetrating rupture of the duodenum may be considered to offer a better prognosis than formerly. The treatment of shock, availability of blood and blood substitutes, continuous gastric aspiration and chemotherapy are only a few of the many factors influencing the mortality rate.

The patient should be put at bed rest and all oral intake should be discontinued. It is important to treat any degree of peripheral circulatory collapse which the patient may demonstrate on admission to the hospital. One may question the advisability of giving any sedative to these patients in the early course of their illness;

although if they are suffering intense pain, certainly demerol should be administered. The rationale in using demerol is based upon the fact that it has an atropine-like action and therefore diminishes gastric secretions. Demerol in sufficient dosage will control pain which may not be helped by the administration of morphine. Water and electrolyte balance should be maintained by the parenteral route. Blood and blood substitutes should be instituted early in the treatment of these cases and the administration of these substances should be based upon the indications and requirements. All clinical laboratory data should be recorded as a base line for the progress and course of the patient. Chemotherapy should be administered early following injury. There is no unanimity of opinion about the types of chemotherapeutic agents to be used. Because there is no knowledge of the type of organisms present either in the peritoneal cavity or in the extraperitoneal spaces, a "gunshot" method of administration must be used. Penicillin at the rate of 300,000 units per day should be given. In our opinion streptomycin should also be administered; this is given at the rate of 0.5 Gm. twice daily. Intravenous sulfadiazine may be given; and if it is used, a blood level of between 8 and 12 mg. per cent should be maintained.

These patients should be observed frequently for two to eight hours and careful notes recorded as to the physical findings in the abdomen at various intervals. We believe that these patients need not be rushed to the operating room for immediate exploratory laparotomy as advised by some observers. If the patient's condition is satisfactory, if the state of peripheral circulatory collapse has been corrected and if the tentative diagnosis has been established, unquestionably operation can be done without delay. Usually these conditions are not encountered. In our experience with continuous gastric aspiration and general supportive measures including chemotherapy, the condition of the patient improves permitting a more accurate diagnosis. This may require twenty-four hours or more. In those instances when there is associated injury to other abdominal viscera, the possibility of selecting an optimum time for operation is enhanced. The correct diagnosis is usually made by roentgenographic studies which require time. Once the diagnosis of a ruptured duodenum, either intra- or extraperitoneal, has been made, operation should be performed. At the time of

exploration the patient must have supportive therapy and whole blood should be available.

*Operative.* Exploration of the abdominal cavity should assure the surgeon that no pathologic lesion has been overlooked. Intraperitoneal rupture of the duodenum should be demonstrated without much difficulty. In our experience the rents have occurred at the junction of the second and third portions of the duodenum. The edges of the tear are usually irregular and there has been considerable edema in the duodenal wall. Adequate surgical repair is based upon good approximation of the mucosal surface using a Connell suture of continuous gastrointestinal No. 000 chromic catgut. The muscular and serosal coats of the duodenum are reinforced with either interrupted sutures of silk or the Halsted mattress sutures of medium silk. In any instance the reinforcement layer is important and must be properly placed and adequate to support the initial catgut suture in the inner mucosa. The use of drainage depends on the degree of infection and the amount of devitalized tissue in the region. Cigarette drains are used and we advise that they be brought out from the peritoneal cavity through a stab wound rather than through the working incision.

In the case of extraperitoneal rupture of the duodenum the operative treatment is somewhat different and therefore warrants some explanation. In this instance the rent in the duodenum is not clearly seen and is frequently diagnosed by the presence of a hematoma in the base of the mesocolon. The duodenum may be edematous and discolored by the presence of a retroperitoneal clot or collection of bloody fluid. The duodenum is mobilized and explored by incising the posterior parietal peritoneum along the right lateral border of that organ. This is an avascular area and there is slight change of damaging any major structures. The duodenum may be mobilized toward the left gutter and the rupture easily demonstrated. The same type of operative repair is advocated and the retroperitoneal area is always drained. Emphasis is placed on the possibility of rupture of the fourth portion of the duodenum. This is the most difficult portion to explore in a retroperitoneal fashion and, therefore, care must be taken not to damage major vessels, particularly the superior mesenteric and middle colic arteries.

The combination of intraperitoneal and extraperitoneal rupture of the duodenum can

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occur and such cases have been reported. This, however, does not change the operative technic for closure and simply indicates that one may have both peritoneal and retroperitoneal reaction from such a wound,

*Postoperative.* Postoperatively these patients should be given the consideration of any patient who has undergone gastrointestinal surgery. Usually the patient is kept in a semi-Fowler position. The stomach is constantly decompressed by continuous gastric suction. Water and electrolyte balance is maintained by parenteral administration. Chemotherapy should be continued, using penicillin, streptomycin and perhaps sulfadiazine in the dosage mentioned. Chemotherapy should be used for ten days postoperatively unless complications from infection demand continuation of the drugs. Sensitivity tests of the cultured organisms will indicate the specific chemotherapeutic agent to be used.

It should be apparent that with proper preoperative management, adequate correction of the rupture of the duodenum by operation and sustained management in the postoperative phase, these patients should survive such an injury. There is some reason to doubt that the mortality rate of 75 to 90 per cent should continue in these patients. Four cases of traumatic non-penetrating rupture of the duodenum due to violence are being reported, with recovery of all four patients.

#### CASE REPORTS

CASE I. H. B. (C. G. H. No. 171946), a thirteen year old white male, was admitted to the Cincinnati General Hospital at 9:00 P.M., April 24, 1942. The history revealed that at 3:30 P.M. April 23, 1942, about twenty-nine hours before admission to the hospital, he had fallen about 7 feet from a tree house, landing on his back. He complained of generalized abdominal pain and about two hours after the accident became nauseated and did not eat. His pain became more manifest in the right lower quadrant of his abdomen and he did not sleep well during the night. The next day the pain, which was colicky in nature but also steady most of the time, gradually became worse; and after he had vomited several times and experienced anorexia, his mother brought him to the hospital.

On physical examination his temperature was 100.4°F., the pulse was rapid and weak with a rate of 160, respirations were 36 and the blood pressure was 90 systolic. Correct diastolic pressure could not be obtained. He was extremely ill with evidence of peripheral circulatory collapse. The examination



FIG. 1. Roentgenogram demonstrating the retroperitoneal fistula due to extraperitoneal rupture of the second and third portions of the duodenum.

was negative except for the abdomen in which there was slight distention with rather marked spasm of all of the abdominal musculature, most marked on the right side. Tenderness was more severe in the right lower quadrant. Rebound tenderness was present throughout but was most marked in the right lower quadrant. An occasional peristaltic movement could be heard in the extreme left abdomen but none was elicited elsewhere. No masses could be palpated. Rectal examination was non-contributory.

The white blood count on admission to the hospital was 32,400 and, except for an occasional cast, urinalysis was negative.

The clinical diagnosis was possible acute appendicitis and the possibility of rupture of a portion of the gastrointestinal tract was also considered. Because of the localization of the intra-abdominal disorder to the right lower quadrant, acute appendicitis was considered most likely even with the history of this trauma and operation was performed eight hours after admission to the hospital. A McBurney incision was made and the peritoneal cavity in the right lower quadrant was explored without revealing any evidence of acute appendicitis. A retroperitoneal exploration was performed by incising the posterior parietal peritoneum. This permitted the escape of a large amount of rather clear, watery fluid which had no odor. It was then believed that there was a retroperitoneal disorder, the etiology of which was undetermined at the time. The retroperitoneal space was drained with five cigarette drains brought out through the McBurney incision. Preoperatively as well as operatively this patient was treated for his peripheral circulatory collapse. Preliminary roentgenograms of the abdomen in-

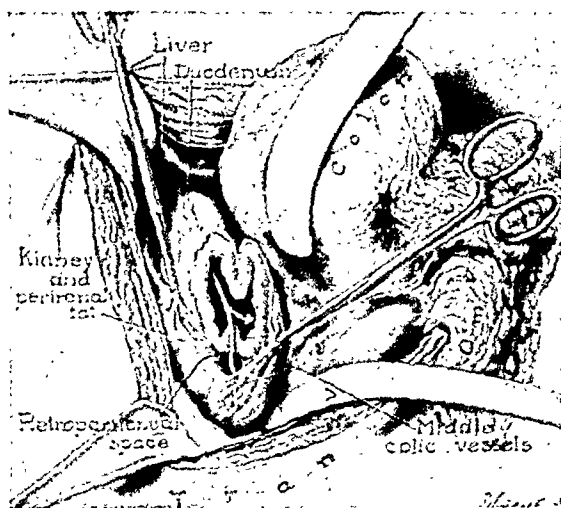


FIG. 2. Drawing representing extraperitoneal rupture of the second and third portions of the duodenum.

cluding a flat and upright film did not reveal any positive findings.

The patient tolerated this procedure fairly well; however, it was noted that his course was quite stormy. His temperature ranged between 99 and 104°F. during the first week. Supportive measures included the administration of whole blood, continuous gastric aspiration, intravenous administration of sodium sulfadiazine, the continued use of intravenous vitamin therapy and good nursing care. Finally his condition did improve and in an attempt to evaluate his condition further an upper gastrointestinal series was done. This revealed a duodenal fistula into the retroperitoneal space dissecting through this region to the right lower quadrant. (Fig. 1.) These films were taken on the patient's sixth and seventh hospital days, respectively. The roentgenologic examination was done because the McBurney incision continued to drain thin, watery material which caused considerable digestion of the epithelial structure of the abdominal wall and looked not unlike that of a pancreatic fistula. Further study of this material revealed that it contained pancreatic juice. This was the first suggestion that the duodenum might have been ruptured. Roentgenographic studies clearly defined the diagnosis. On the patient's tenth hospital day (eleven days after the initial fall) this patient submitted to exploratory laparotomy through an upper transverse abdominal incision. The duodenal region was immediately explored; and after the duodenum was mobilized by incision of the right lateral peritoneum, the second and third portions of the organ were easily mobilized. The duodenum was rotated toward the left gutter and a rent which almost encircled the duodenum half of its distance was seen at the junction of the second and third portions of its structure. (Fig. 2.) The wall of the duodenum was edematous and the

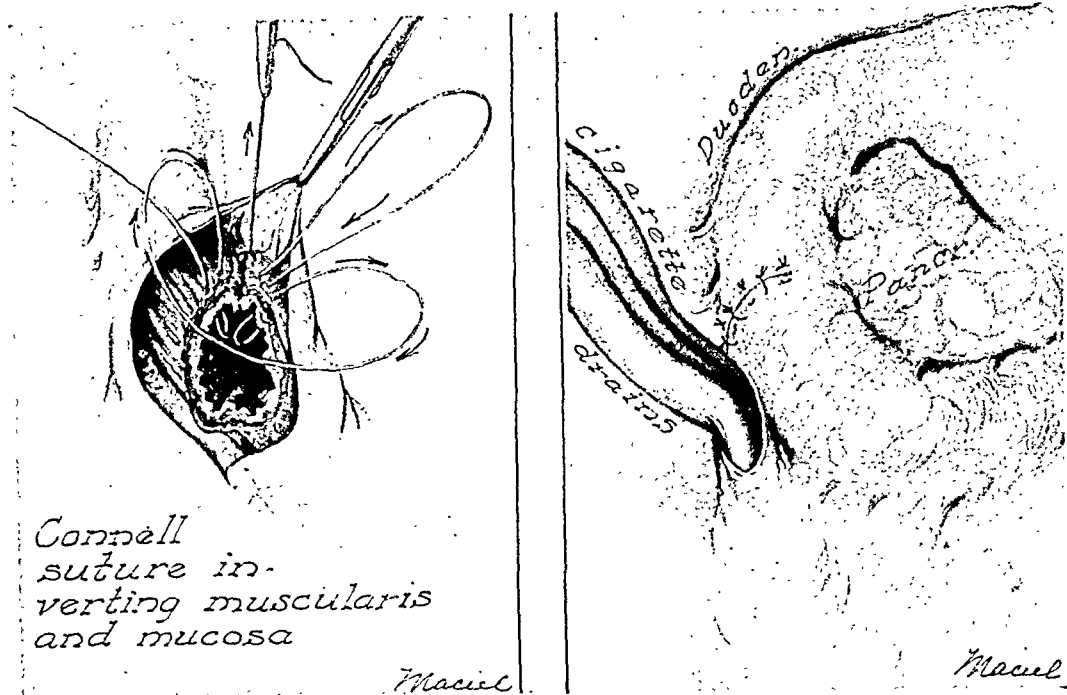


FIG. 3. Drawings demonstrating the technic of closure of extraperitoneal rupture of the duodenum.

edges of the rupture were somewhat irregular and devitalized. The mucous membrane was seen to protrude very distinctly through this tear. The mucosa was closed with a continuous No. 00 intestinal chromic catgut suture using the Cushing right angle stitch. The muscular coat was then used to reinforce the mucosal suture by means of the Halsted mattress suture with medium silk. Between each of these mattress sutures an interrupted suture of fine silk was placed. This adequately repaired the duodenum at the point of rupture. (Fig. 3.) Five cigarette drains were then placed in the retroperitoneal space and these drains were brought out through the right lateral angle of the working incision. The incision was then closed with through and through silver wire stay sutures. Five Gm. of sulfanilamide were placed in the peritoneum. No attempt was made to close the peritoneum and fascial structures of the anterior abdominal wall.

He was given all of the supportive measures which follow such an operative procedure, namely, gastric aspiration, sodium sulfadiazine, maintenance of water and electrolyte balance by parenteral fluids, the adequate utilization of whole blood intravenously and adequate doses of vitamins daily. His response postoperatively was excellent, his temperature ranging between 99 and 102°F. for four to five days after which it gradually returned to a normal level. On the sixteenth post-operative day his temperature was normal; he was discharged from the hospital as well on the forty-first hospital day.

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**Comments.** This is an example of an extraperitoneal rupture of the duodenum due to violence. This case represents an example of misinterpretation of an extraperitoneal rupture of the duodenum with retroperitoneal extension of duodenal secretion to the right lower quadrant. The initial clinical diagnosis was acute appendicitis.

**CASE II.** L. B. (C. G. H. No. 157711), a white male age twelve, was brought to the Cincinnati General Hospital on June 2, 1945, two hours after he had received injuries to the abdomen and left forearm. This child had been crushed between a truck and a boxcar. His complaints at the time of admission concentrated about the abdomen where there was tenderness in the epigastric region. He complained also of pain in his left wrist.

Physical examination was essentially negative except for the abdominal findings. Temperature was 100°F., pulse 88, respirations 28 and the blood pressure was 130 systolic over 90 diastolic. Examination of the abdomen revealed right rectus muscle spasm chiefly located in the right upper quadrant with questionable rebound tenderness. There was evidence of shifting dullness, revealing clinically the presence of fluid in the peritoneal cavity. Peristalsis was absent. On rectal examination there was mild tenderness on both sides. There was a Colles' fracture of the left wrist.

The clinical diagnosis was Colles' fracture of the left wrist, possible contusion of the liver and possible rupture of a hollow viscus. The patient was



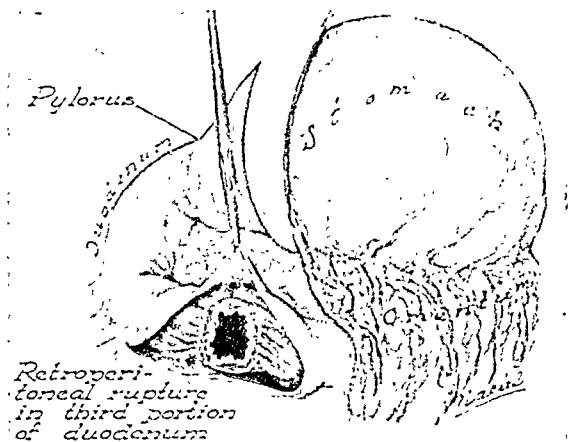


FIG. 4. Drawing representing extraperitoneal rupture in the third portion of the duodenum.

placed on surgical observation after treatment of the Colles' fracture. In the interim of a few hours he vomited three times. The vomitus consisted of gastric material which did not reveal the presence of blood. He definitely became more apprehensive and within four hours the pain in the right upper quadrant and the epigastric regions increased. There was evidence of right rectus rigidity with rebound tenderness referred to the right side. A left decubitus roentgenogram revealed no air in the peritoneal cavity. At this time the white blood count, which on admission was 11,300, had risen to 28,350. Within eight hours after the accident the temperature rose to 101.6°F., the pulse increased to 120 and the respirations were 28. There were definite signs of increasing peritoneal irritation and the patient became markedly drowsy. The entire right abdomen was rigid and exquisitely tender. At this time the definite diagnosis of a ruptured hollow viscus, probably in the duodenum, was made. The patient was prepared for operation by the administration of 1,000 cc. of 5 per cent glucose and saline; ten hours after the injury he submitted to exploratory laparotomy.

Operation was done through an upper transverse incision. Beneath the right portion of the gastrocolic omentum there were collections of fluid of a greenish yellow color strongly resembling the appearance of bile. The fluid had dissected down to the right lumbar gutter in the retroperitoneal space and also upward toward the foramen of Winslow. The greatest concentration of the fluid was at the base of the mesocolon in front of the right kidney at the junction of the second and third portions of the duodenum. The retroperitoneal space was entered by incising the peritoneum to the right of the second portion of the duodenum. The bile-stained fluid was aspirated and by sharp and blunt dissection the second portion of the duodenum was exposed. A laceration was found which extended approximately halfway around the

duodenum in a transverse direction just at the junction of the second and third portions. (Fig. 4.) Bile poured freely from the laceration. The second and third portions of the duodenum were mobilized so that both sides of the area of laceration were adequately exposed. Traction sutures of silk were placed at either end of the laceration and the mucosa was closed with a running lock stitch of No. 000 chromic intestinal catgut. This suture line was reinforced with Halsted mattress sutures of medium silk and interrupted sutures of fine silk were placed between each Halsted mattress suture. Two cigarette drains were placed in the retroperitoneal space and one Penrose drain in the right paravertebral gutter. The abdominal wound was then closed with through and through wire sutures. The drains were brought out through a stab wound just below the twelfth rib. The posterior rectus sheaths and peritoneum were closed with No. 0 chromic catgut and the anterior rectus sheaths were closed with interrupted No. 0 chromic catgut sutures. The edges of the skin were approximated with interrupted sutures of fine silk. A Levin tube was placed in the stomach while the patient was still under anesthesia and he was returned to the ward in good condition.

The postoperative course was essentially uneventful. The patient was given nothing by mouth for a period of seventy-two hours after which time he was started on a Cornell diet. He was given parenteral fluids and chemotherapy in the form of penicillin and sulfadiazine. His temperature postoperatively ranged around 102.6°F., the pulse between 100 and 120 and the respirations between 30 and 44. All of these clinical observations gradually fell so that by the eighth postoperative day they could be considered within normal limits. On the tenth postoperative day the patient began to have an intermittent fever. This type of febrile response was not explained except on the basis of possible reaction to the chemotherapeutic agents. The possibility of subphrenic abscess was also considered. X-ray and fluoroscopy of the diaphragms and thorax did not reveal the presence of a subphrenic abscess. Repeated examination of the chest and diaphragms revealed no pathologic condition and at this time the white blood count was within normal limits. By the thirteenth postoperative day the temperature, pulse and respirations were within normal range and remained so until the patient's twenty-fourth hospital day at which time he was discharged. Sulfadiazine was discontinued on the tenth postoperative day and penicillin was discontinued on the seventeenth postoperative day.

This patient was watched in the surgical follow-up clinic. He has been seen eleven times since this accident occurred, the last visit having been February 15, 1948. At no time have there been any complaints referable to the gastrointestinal

tract and his postoperative course has been considered excellent in all respects. There was no evidence of hernia in the transverse abdominal incision.

*Comments.* This is an excellent example of a non-penetrating extraperitoneal rupture of the duodenum due to violence diagnosed eight hours after the injury and operated upon ten hours after the injury.

CASE III. A. P. (C. G. H. No. 213967), a forty-nine year old white male, entered the Cincinnati General Hospital on the orthopedic service because of a tumor mass in the region of the right ilium. He entered the hospital May 20, 1946, after having been seen in the gastric clinic the same day. The history revealed that he had fallen on a rock five months before admission to the hospital and had injured his right side, particularly the right pelvis. Immediately after this accident he remained in bed for about two days with pain in the abdomen and over the right pelvic region. This pain continued for a period of about four days and then tended to subside although the patient stated that he did not feel well during this interval. Three months before admission he began to have sharp, knife-like gas pains in the lower abdominal region; these were continuous both day and night with disturbance of bowel habits in the nature of obstipation and constipation. At this time the patient had a weight loss of 28 pounds in three months. The remainder of his history was essentially negative.

Physical examination revealed his temperature to be 98°F. on admission with pulse 68 and respirations 20. The white blood count in the admitting ward was 19,000. Examination was for the most part negative except in the abdomen. Here over the right iliac crest a large, circular, intra-abdominal mass measuring approximately 8 by 10 cm. could be palpated. This was exquisitely tender and very painful to palpation. There was a suggestion of fluctuation of this mass although the observers could not agree on this finding. Most observers agreed that the mass lay in the retroperitoneal tissues. The remainder of the abdominal examination was essentially negative.

The working clinical diagnosis covered many possibilities including osteomyelitis of the ilium, retrocecal abscess, perinephritic abscess, ruptured duodenal ulcer with subphrenic abscess, malignancy of the ascending colon and malignancy of the right kidney. Among many clinical determinations a barium enema was done which revealed a definite constricting angular lesion of the mid-ascending colon. These findings were compatible with a primary malignancy of the ascending colon. However, the roentgenologist believed that the soft tissue mass might represent a second pathologic

lesion and, therefore, an abscess from a perforated carcinoma of the colon was considered as a likely possibility. The patient's general condition was good. During the course of observation the temperature, pulse and respirations rose gradually so that by the third hospital day his temperature ranged around 102°F. at which time his white count varied between 10,000 and 17,000. The pulse was also elevated during this period and respirations ranged between 20 to 24. On the fourth hospital day the patient was placed on penicillin therapy which was continued for a long period of time. The roentgenologic findings also suggested possible involvement of the wing of the right ilium and for this reason the patient was admitted to the orthopedic service. Although he was presented to the orthopedic staff, it was believed that a good possible diagnosis was that of a retroperitoneal tumor or abscess. It was suggested that medical and surgical consultation be obtained. The medical consultants believed a likely diagnosis to be osteomyelitis with abscess formation of the right ilium. Both acute and chronic osteomyelitis were considered as a possibility. It was the opinion of the surgeons that this patient could have one of many possibilities; however, both inflammation in the nature of a retroperitoneal abscess and the possibility of a primary carcinoma of the ascending colon with perforation were considered to be the most likely possibilities. It was the suggestion of the surgical department that this patient have a drainage of his abscess and that a biopsy of pertinent tissue be taken at that time.

On June 7, 1946, the patient's eighteenth hospital day, incision and drainage of the abscess was done. At this time the patient was placed on chemotherapy consisting of both penicillin and sulfadiazine. Very promptly there was response and his temperature, pulse and respirations returned to a normal limit. Biopsy was done at this time but was non-specific as far as diagnosis was concerned. The patient then had a repeat examination of his barium enema at which time the roentgenologist considered carcinoma of the ascending colon as a likely diagnosis. (Fig. 5.) The diagnosis of an infected granuloma was all that could be considered from the biopsy. Because of the findings in the mid-ascending colon it was believed that definitive therapy should be established. Therefore, on June 22, 1946, the patient's thirty-third hospital day, he was operated upon with a tentative diagnosis of carcinoma of the ascending colon with perforation and abscess formation of the right flank. The abdominal cavity was explored through a transverse incision which was started about 2 cm. above the right anterior iliac spine and extending to just beyond the midline about 3 cm. below the umbilicus. There was no free fluid in the peritoneal cavity. The liver, gallbladder and stomach appeared to be normal. The

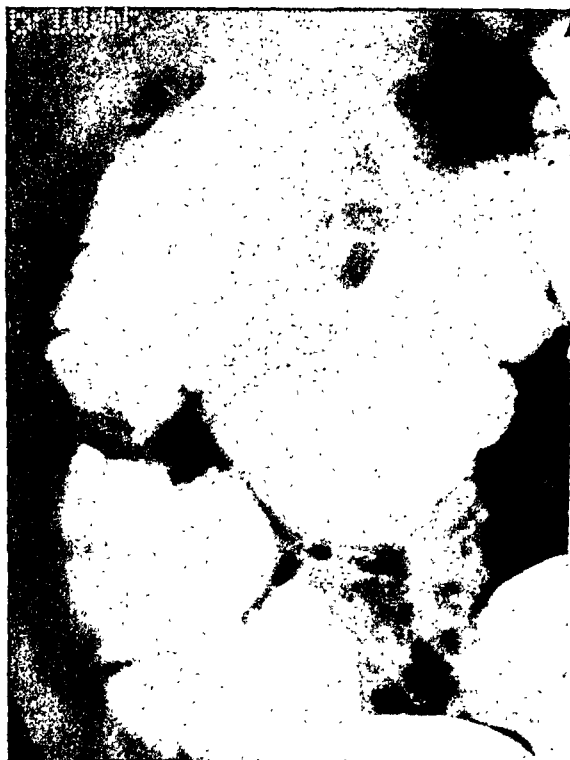


FIG. 5. Roentgenogram (barium enema) showing annular constriction of the mid-portion of the ascending colon; this constriction was proven to be due to adhesions from a previously extraperitoneally ruptured duodenum.

mid-portion of the ascending colon was densely bound down by adhesions. These adhesions apparently were so placed in the mid-ascending colon as to produce an annular constricting appearance in the roentgenograms studied by barium enema. The cecum was free and the appendix and ileum appeared normal. There was no mass in the region of the ascending colon. The origin of the abscess in the right flank was apparently from a retroperitoneal point. It was decided to explore the hepatic flexure of the colon and the adhesions in this region were incised in order to mobilize the bowel. As the hepatic flexure was finally freed, the second and third portions of the duodenum were exposed. There were numerous extremely dense fibrous adhesions between the hepatic flexure of the colon and the junction of the second and third portions of the duodenum. Final exploration of this region revealed an old laceration of the duodenum in its second and third portion which had been sealed off by granulation tissue for a long period of time. There was no evidence of a duodenal ulcer in this location and certainly no evidence of tumor. By mobilizing the peritoneum to the right side of the second and third portions of the duodenum and rolling this part of the duodenum anteriorly and to the left laterally, the retroperitoneal tear was

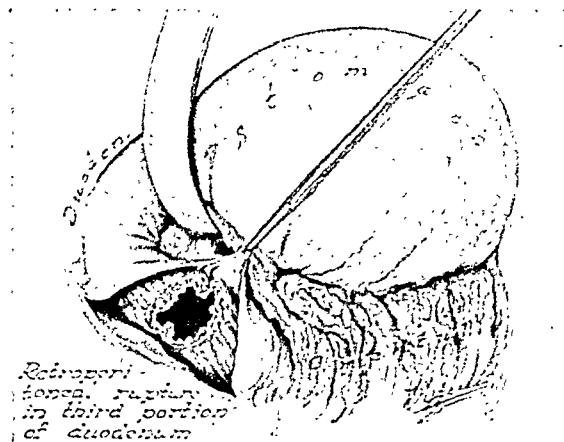


FIG. 6. Drawing representing extraperitoneal rupture of the third portion of the duodenum.

found. This tear was about 3 cm. in length and was in an oblique position. (Fig. 6.) The mucosa of the tear was closed with a No. 000 chromic intestinal catgut suture of the Cushing right angle type. The serosa and muscular coats were reinforced with Halsted mattress sutures of medium silk and between each of these an interrupted suture of fine silk was used for reinforcement. There was considerable scar tissue and adhesions about the lower pole of the right kidney and there was evidence of a sinus tract which led posteriorly and retroperitoneally inferior to the pole of the kidney and anterior to the iliopsoas muscle. This sinus tract communicated with the old abscess which had previously been drained. Four cigarette drains were placed in this retroperitoneal region and brought out through a separate stab wound in the right flank. The abdominal working incision was then closed with through and through steel wire stay sutures and the peritoneum and posterior rectus sheath closed with a continuous No. 0 chromic catgut suture. The anterior rectus sheaths were not closed. The edges of the skin were approximated with interrupted sutures of fine cotton.

The postoperative course from this point was excellent and there was little or no febrile response to the operative procedure, the temperature having risen to 101°F. for one twenty-four-hour period after which it remained essentially normal. He was given supportive therapy in the form of whole blood and blood plasma and chemotherapy was continued in the form of sulfadiazine and penicillin. The wound healed without infection and the patient was discharged from the hospital on his twelfth postoperative day and his fifty-third hospital day.

This patient has been seen five times in the surgical follow-up clinic and it is the opinion of all clinicians that he has made an uneventful recovery. He was last seen September 15, 1946, at which time he had no complaints referable to his gastro-

intestinal tract. The abdominal wound was well healed and there was no evidence of hernia.

*Comments.* This is an excellent example of traumatic rupture of the duodenum of the retroperitoneal variety. The process of infection was walled off so that an acute to chronic retroperitoneal abscess developed which pointed in the right lower quadrant as a large indefinite mass. In this process a sinus tract developed between the second and third portions of the duodenum to the right lower quadrant. The infection remained localized over a long period of time so that there were definite changes in the appearance of the wing of the right ilium and, therefore, the diagnosis of involvement of bone was made. Because of the chronicity of this affair and because the adhesions constricted the wall of the ascending colon externally, the diagnosis of carcinoma of the ascending colon with perforation of the carcinoma and abscess formation was considered the most likely preoperative diagnosis. At operation the rupture of the duodenum was closed and the patient made an uneventful recovery.

**CASE IV.** R. M. (C. G. H. No. 246425), a thirty year old white male, was admitted to the Cincinnati General Hospital almost immediately after having had a head-on collision in his automobile. He was admitted on January 1, 1949, approximately one hour after the injury. His history revealed that when he had the head-on collision, he attempted to cover his face with both hands; and in so doing he turned toward the left so that his right upper abdomen was forcibly thrust against the steering wheel of his automobile. He had been drinking and there was some element of confusion about the incidents that followed immediately after this injury.

On clinical examination his temperature was found to be 97.6°F., pulse 84 and respirations 20. The blood pressure was 104 systolic over 60 diastolic; the white blood count was 26,800. The general physical examination was essentially negative except for the abdominal findings of severe tenderness in the right upper quadrant with marked tenderness over the right thoracic cage anteriorly and laterally. There was marked muscle spasm of the upper abdominal muscles and rigidity over the right upper quadrant. Peristalsis was absent. There was rectal tenderness diffusely but no evidence of localization. Roentgenograms consisting of a flat and an upright film of the abdomen were negative for the presence of pneumoperitoneum. Possible laceration of the liver, possible fractured ribs and the possibility of acute traumatic pancreatitis and of a ruptured hollow viscus



FIG. 7. Roentgenogram demonstrating intraperitoneal sinus due to rupture of the third portion of the duodenum.

were considered as likely diagnoses. This patient was admitted to the surgical service and observed over a period of several hours. Within eight hours after admission the patient vomited on two occasions and the serum amylase was found to be elevated to 564 units with a white count ranging around 25,000. The patient was placed on continuous gastric suction and given nothing by mouth. He was also given chemotherapy in the form of penicillin and streptomycin. Because of the elevated blood serum amylase the diagnosis was limited to two possibilities, acute traumatic pancreatitis and the possibility of a ruptured duodenum. As a matter of fact, most of the clinicians who saw this patient considered both of these possibilities. The patient maintained a relatively normal plateau and in the course of forty-eight hours appeared to be somewhat improved although his temperature was still elevated between 100 and 101°F. and the serum amylase was maintained about 600 units. By the end of seventy-two hours the white count began to rise. Because of the absence of peristalsis and because of the septic course and the elevated white blood count roentgenograms of the abdomen, including fluoroscopy of both diaphragms, was done on the patient's

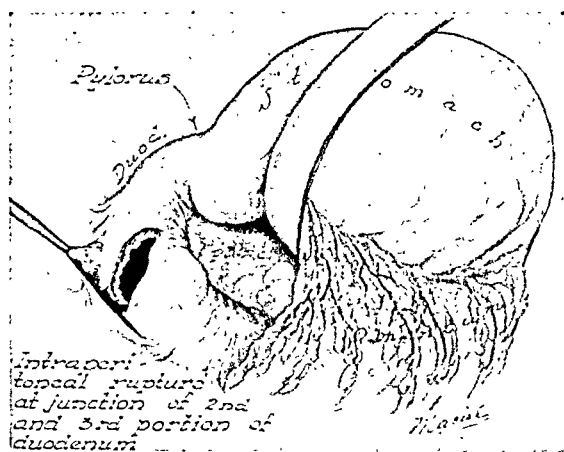


FIG. 8. Drawing representing intraperitoneal rupture of the second and third portions of the duodenum.

fourth hospital day. Also at this time 15 cc. of iodized oil were introduced through the Levin tube in the patient's duodenum. This iodized oil was seen to pass through the duodenum and, as it entered the second and third portions of the duodenum, it passed into a sinus tract which lay over the anterior aspect of the right iliopsoas muscle paralleling the angle of the duodenum. This oil extended from the duodenum for a distance of approximately 6 cm. On the basis of this roentgen study (Fig. 7) a diagnosis of traumatic perforation of the descending arm of the duodenum with a large-sized sinus tract proceeding caudally in the retroperitoneal space was made. This patient was observed because of the definite proven diagnosis of acute traumatic pancreatitis. It was the belief of the clinicians that although the patient did have a rupture of the duodenum, his general condition was excellent; and, therefore, early exploration in the presence of the traumatic pancreatitis would not have been considered as good judgment as careful observation.

On the patient's tenth hospital day exploratory laparotomy was done through an upper transverse incision at which time a transverse tear at the junction of the second and third portions of the duodenum in the intraperitoneal portion was found. (Fig. 8.) There were considerable adhesions about this portion of the gastrointestinal tract between the omentum, transverse colon and the duodenum. The omentum and transverse colon were freed by cutting these adhesions and a rent which was approximately 3 cm. in length and ran obliquely across the second and third portions of the duodenum was encountered. The edges of the duodenal wall were hemorrhagic and edematous. The mucosa was approximated with a continuous No. 00 chromic intestinal Connell suture. (Fig. 9A.) The muscular and serosal coats of the duodenum were reinforced with Halsted mattress sutures of medium silk and interrupted sutures of fine silk were placed between each of these mattress sutures. (Fig. 9B.) This gave adequate closure of this perforation of the duodenum. Two Penrose drains were placed to this portion of the duodenum and were brought out through a separate stab wound in the right flank. The upper transverse incision was then closed with through and through steel wire sutures, the peritoneum and posterior rectus sheaths having been approximated with No. 00 chromic catgut sutures. The anterior rectus sheaths were also approximated with interrupted No. 00 chromic catgut sutures and the edges of the skin were approximated with fine silk sutures.

The patient responded well to this operative procedure. All general supportive measures were used including whole blood and blood plasma. Chemotherapy in the form of penicillin and sulfadiazine was given and on the patient's fourth post-operative day his temperature, pulse and respirations fell within a normal limit. Chemotherapy was continued until the patient's seventh post-

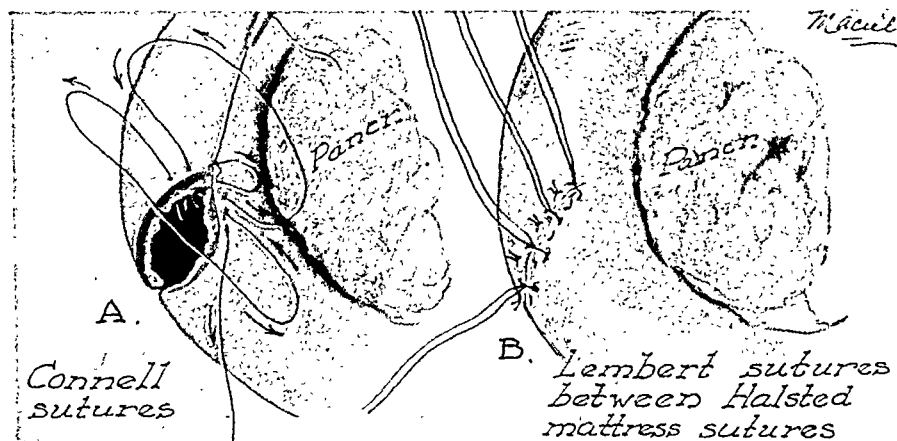


FIG. 9. A, drawing demonstrating the Connell suture to invert the mucosa and muscularis layers of the duodenum; B, drawing demonstrating reinforcement of the mucosomuscularis suture using Halsted mattress sutures and interrupted sutures.

operative day at which time they were discontinued. The patient had no complications whatever and was discharged on his twenty-fifth hospital day.

*Comments.* This is an example of an intraperitoneal acute rupture of the duodenum due to violence associated with acute traumatic pancreatitis. It is questionable whether the patient should have been explored earlier in the course of this illness although his response to this operative procedure as late as the tenth post-traumatic day was excellent. Had he been operated upon earlier within the first twenty-fourth to forty-eight hours, one might question whether or not further damage would have been done to the pancreas with a resultant stormy postoperative course.

#### SUMMARY

A series of four acute ruptures of the duodenum due to violence has been reported. One of these cases (Case iv) represents intraperitoneal rupture of the duodenum while Cases i, ii and iii represent retro- or extraperitoneal rupture of the duodenum. Interestingly enough these are the only four cases which we have seen in the Cincinnati General Hospital between the years 1942 and 1949 inclusive. The mortality rate from this type of trauma has been reported to be between 75 and 90 per cent. There was no mortality in the four cases presented. It is to be noted that all four of these cases are different in all respects. In Case i the diagnosis of acute appendicitis with abscess formation, which proved to be erroneous, was made. In Case ii the diagnosis was made early in the post-traumatic period and the patient was operated upon within ten hours. In Case iii the acute rupture of the duodenum apparently was walled off readily. Therefore, a long-standing retroperitoneal abscess developed which pointed in the patient's lower right quadrant and in so doing created adhesions about the mid-portion of the ascending colon. These complications permitted the erroneous clinical diagnosis of carcinoma of the colon with perforation and abscess formation. This patient was operated upon approximately five months after the perforation had occurred. In Case iv the diagnosis of rupture of the duodenum was considered early in the post-traumatic period. However, the positive diagnosis of traumatic pancreatitis was made by the laboratory determination of an elevated blood serum amylase. In this instance the

patient's condition improved and, therefore, exploration was delayed because of the likelihood of disturbing the pancreatic condition. The patient was operated upon on his tenth post-traumatic day and made an uneventful recovery. Unquestionably chemotherapy has done a great deal to improve the survival rate.

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#### DISCUSSION OF ARTICLES BY DRS. DEVINE AND BURWELL, SANDERS, MAGUIRE AND MOORE, WECKESSER, CHINN AND SCOTT, AND SILER

J. MAXWELL CHAMBERLAIN (New York, N.Y.): It is a pleasure to be able to discuss these very interesting papers before this Society. As a thoracic surgeon I should like to limit my discussion to the thoracico-abdominal incision as pointed out in the paper by Dr. Devine and Dr. Moore.

There are two points of interest to me. These have to do with anesthesia and the care of the open chest postoperatively. As Dr. Devine pointed out, he did not have an intratracheal tube in place; and I should like to emphasize that the intratracheal tube, although desirable, is not essential. As you all know, when the chest is opened, the tidal exchange of air is immediately reduced; but with a tight-fitting mask and intermittent or rhythmical compression of the anesthetic bag this reduction in tidal excursion can be compensated for by the anesthetist. If the tidal air under pressure which enters the pharynx goes via the esophagus into the stomach, the abdomen is already open; and the surgeon is immediately aware of this. Usually, however, the sphincteric tone of the cardia is such that the stomach does not inflate during the compression by the anesthetist.

Now, in the postoperative care of the open chest perhaps the safest thing to do is to drain or put a catheter into the pleural space postoperatively and drop this tubing down beneath water. It is not essential. One may put in penicillin or some other drug to combat a possible infection but there is really no reason to substitute chemotherapy for good surgical principles. As we all know, obliteration of dead space is one of the first principles of surgery. If complete re-expansion of the lung is achieved by drainage of the pleural space using a water seal to prevent the air from getting back into the thorax, infection is not likely to occur. In twenty-four to forty-eight hours this tube is removed.

It is a pleasure to see the modern, well trained general surgeons enter the thorax with no fear. If proper anesthesia is used and proper care of the chest is observed postoperatively, there should be no hesitancy on the part of the surgeon to open the chest and achieve the necessary exposure which is essential to good surgery.

R. ARNOLD GRISWOLD (Louisville, Ky.): The only thing I would like to point out with reference to these wounds of the liver is the advisability of debriding the liver just as you would debride any other tissue. Surgeons traditionally are afraid of the liver because of the danger of hemorrhage. As you saw in Dr. Moore's second case, the liver was

not débrided. That man had secondary hemorrhage and almost died. In the first case, in which the patient got along very well, the autolyzed liver tissue was débrided.

Dead liver tissue not only is a great cause of secondary hemorrhage but also is extremely toxic if left in the abdomen. Therefore, I should like to enter a plea for adequate surgical débridement of the liver just as you débride any other contused, dead or damaged tissue.

JOHN L. ATLEE, JR. (Lancaster, Pa.): I am very glad to have the opportunity to discuss these cases, particularly the liver injuries.

I think the most important thing in all of these cases is to know when to operate. Too often one sees deferment of decision as to when to do it. Our experience has been rather limited. We had one case that was packed with oxidized cellulose in which the liver was not débrided and which was troubled with secondary hemorrhage. We had another case that was not so massive in which the liver was débrided and in which gelfoam was used. I have no thought about either particular hemostatic substance. It seems to me they are both good. The second case did not have any hemorrhage.

I should like to impress one factor, that is, to be prepared to make a thoracico-abdominal approach.

One other patient, a child, had a laceration of the spleen associated with injury to the left lobe of the liver and to the stomach from a falling anvil on a farm. I am sure that case could never have been handled in any other way than by thoracico-abdominal approach.

EVERETT P. COLEMAN (Canton, Ill.): I should like to discuss the paper on massive resection of the intestine and report two cases with which I have had some interesting experiences. The term, massive resection, has been coined to apply to intestinal resections with the arbitrary limit of 5 feet; that is, anything over 5 feet is listed as a massive intestinal resection.

The first case was that of a middle-aged woman who was seen about twelve years ago with a recurring jejunal intussusception which had been compounded four times. At the time of operation the inner layers of this intussusception were found to be gangrenous and a resection of 5 feet 6 inches of bowel was found necessary. In this case all the jejunum was removed and a portion of the upper ileum. In spite of the loss of secretions from the jejunum, which are supposed to stimulate further intestinal secretions for the aid of digestion, she has had no unusual symptoms. Her postoperative course has been entirely uneventful and there are no digestive symptoms of any type. She can eat anything and has no anemia or diarrhea. She has had a moderate gain in weight and when last seen was restricting her diet somewhat to avoid the "middle-aged spread."

The second case gave an entirely different post-

operative picture. The patient was a young man who received a shotgun wound of the abdomen with extensive destruction of the right half of the colon and practically all of the ileum. At operation it was found necessary to remove 15 feet 8 inches of intestine. In this case all of the ileum and the right half of the colon were removed. After a very stormy recovery period he seemed to be in fairly good condition but I have had the opportunity for the last eight years to observe him at intervals. Most of the time he has been quite troubled with diarrhea, particularly when he ate food with a large amount of fat in it. He has been rather emaciated although he was of this type of build prior to his injury. He seemed to do best on a high carbohydrate diet with quite a little protein but being a fisherman, on occasion temptation was too great to be resisted and he would go on a "bat" of fried catfish and corn on the cob. As a result he comes to the hospital from time to time with a very intractable diarrhea. We put him on a high carbohydrate and protein diet and he will get along quite nicely; the diarrhea will clear up and he will handle food with apparent efficiency of his digestive apparatus so long as he avoids fats. During this period he has taken very poor care of himself from the medical standpoint and, as a result, returns about once a year with a rather profound hyperchromic anemia. According to the blood findings and to sternal puncture it is not a pernicious anemia but simply an iron deficiency anemia and about once a year he has to have about 2,000 cc. of blood. He comes in pretty well down in his red count and hemoglobin with no microscopic blood evidences of pernicious anemia. We will give him four transfusions and then he will gain and go home doing fairly well from the anemia standpoint until the next year. He has learned, little by little, to avoid fried catfish and corn on the cob with occasional exceptions. In our opinion the inability of the jejunum and distal colon to absorb iron from his diet is the major factor in producing the anemia. However, in the past year an interesting change has occurred. In his last hospital stay, nearly a year ago, he was given liver extract hypodermically in addition to his transfusions to help overcome his anemia. A nurse who is employed part time in the hospital lives near him and gives him liver extract hypodermically at weekly intervals. Following this, over a period of several months he has remained free from anemia, has gained in weight and is in a better state of nutrition than at any time in his life. Apparently, with the sole addition of liver extract, with the diarrhea controlling factor of a high carbohydrate and protein diet and with the avoidance of fats, he will now be able to live a fairly normal existence with a minimum of discomfort.

LOUIS G. HERRMANN (Cincinnati, O.): I should like to emphasize some of the things that Dr. Siler has already told you.



We are convinced that these injuries to the duodenum, particularly in the retroperitoneal portion, are much more common than is ordinarily supposed. We believe we should keep in mind this injury to the duodenum in all forms of trauma to the upper abdomen.

Dr. Siler's cases showed that even in well-organized surgical clinics there is considerable delay sometimes in recognizing the injury to the duodenum or in carrying out definitive treatment. It is for the purpose of bringing this syndrome to your attention that Dr. Siler has presented these cases. If we can recognize these lesions early, the mortality rate from this type of injury can be reduced greatly.

H. GURTH PRETTY (Montreal, Canada): I think I have been put on the spot a little here by having the Chairman invite me to discuss these papers but I have been suspecting it for some time.

These papers are particularly interesting because I can recall numerous occasions when these things have happened. In the first place, with all due respect to our present knowledge and treatment, laboratory findings, when I recall some of the old writings of De Quervain, with special reference to rupture of the small gut, I still think that these articles are well worth going back over and rereading.

My experience with rupture of the duodeno-jejunal juncture has been in connection with the pulp and paper industry when they first started using tractors. These tractors went plowing through the mud and suddenly a stick of pulpwood got caught under the tractor. Then men who were following behind were just fired at as though they were hit by a machine gun. On one occasion three men were "picked off" with a stick of pulpwood.

Another point is that on many occasions I have run into rupture of the liver with children playing, throwing balls, etc. I can recall one instance in which a youngster was chasing a tennis ball. The tennis ball bounced back in front of a hydrant. Three other boys piled in behind the boy and drove him up against the hydrant; he got a ruptured liver through the cleft.

Now, I wish that I had known about the thoraco-abdominal approach in those days. I would not have had as much trouble as I had at that time in closing the liver. We did not have gelfoam, vitamins C, K or anything else at that time. All we did was take a piece of the rectus muscle, put it on either side of the liver cleft and then put microsutures through.

I was interested in the point regarding laceration of the liver, that most people were draining it. My experience has been that we were not draining our abdominal cavities. Whether that is introducing more trouble, I do not know. However, I was interested in the fact that these were drained, but in spite of that you were running into subphrenic

abscess. I would like to hear some remarks on that point.

These papers were most interesting, and I think it is a very good series to bring before this Society.

CHARLES G. JOHNSTON (Detroit, Mich.): In the Detroit Receiving Hospital we see rupture of the duodenum occasionally. In the case which Dr. Siler presented last it seemed to me that the patient must have been an exceedingly sturdy man because these patients are very sick. A man who has had a rupture of the duodenum with free blood and obviously duodenal material from a hole as large as he had, must have been a pretty sick individual. The question I wanted to ask him is: How often has he seen the diagnostic feature of fine bubbles of air in the retroperitoneal space, either going down along the psoas, or the thing we have seen (which I have not seen in the literature), fine bubbles of air in under the liver, finely dispersed, on the flat film of the abdomen.

On two occasions we have diagnosed definitively a rupture of the duodenum on the basis of the flat film with small bubbles of air and I think that should always be looked for in any patient. We believe that the flat film of the abdomen is an important adjunct to diagnosis and so far as ruptured duodenum into the retroperitoneal area, it is an exceedingly important and definitive diagnostic picture. If you see it, you can be sure of it. So often we do not see it and I wanted to know from Dr. Siler whether he had observed this in his cases and how many times.

VINTON E. SILER (Cincinnati, O.): I would like to make a comment about Dr. Weckesser's paper.

He brought up the question of how much small bowel can be removed and still have a patient survive. I would like to report that a patient, twenty-seven years of age, entered our hospital a year and a half ago at which time a diagnosis of internal hernia was made. After resection this patient had 18 inches of jejunum left so that a jejunocolostomy was done. This patient was followed up very carefully not only by the surgical department but also by the medical service and has subsequently been observed by Dr. Richard Vilter who has directed complete studies.

When last seen eighteen months postoperatively, he was on a regular diet and had not developed any type of anemia. I think this might be at least an answer to Dr. Weckesser's question. We all realize that this patient might live many months and then, all of a sudden, develop an uncontrollable anemia resulting in death. Many problems in massive resection of small bowel have not yet been answered.

GEORGE B. SANDERS (Louisville, Ky.): I would like to make one or two comments about Dr. Weckesser's paper in regard to the use of Tween-80.

I have at the present time three patients who have been maintained on Tween-80 for about six

months to a year. Two of these patients had right hemicolectomy with accompanying resection of about 3 to 4 feet of small bowel. They did not do particularly well from the nutritional standpoint after operation and were both placed on large doses of Tween-80 anywhere from two to four months after operation.

At that time I had no facilities available for the quantitative study of their stools so that my only evidence of improvement or the effect of Tween-80 was in their gain in weight and in the decrease in number of their stools from six in twenty-four hours to an average of two or three. Both patients manifested this definite change and improvement after being on the Tween-80 for about a week.

The third case is a little more interesting and more satisfactory because this man had an ileostomy for ulcerative colitis. He was maintained for about four months in a rather precarious nutritional balance but doing, we might say, satisfactorily, except that he did not gain weight but maintained a weight of about 75 to 80 pounds. At four months after his ileostomy, at which time I believe that any improvement in his nutritional status from the ileostomy alone would be ruled out, he was placed on Tween-80 and the change in the number of his stools or his ileostomy discharges in twenty-four hours was quite dramatic. They were reduced two-thirds or more after three days of being on Tween-80. He then immediately began to gain weight, adding approximately 35 pounds.

I would like to ask Dr. Siler one question with regard to extraperitoneal rupture of the duodenum. Occasionally there occurs in conjunction with this a very distressing thing, which is rupture of the retroperitoneal or retroduodenal common duct. It is a difficult thing to pick up and in my experience at least once has subsequently caused the death of the patient after we thought everything had been put in order.

I would like to ask, Dr. Siler whether it would not be advisable in each case of retroperitoneal rupture of the duodenum to visualize the papilla of Vater transduodenally and do a retrograde exploration of the retroperitoneal common duct to be sure that this has not occurred.

FRANK H. MAYFIELD (Cincinnati, O.): If a neurosurgeon can get into this discussion, I would like to comment on Doctor Siler's case with pain in the low back and hip. I do not recall whether there was actually a disease of the hip but back and leg pain is not rare with disease of the posterior wall of the duodenum. I have seen a total of six patients whose presenting symptom was low back and hip pain which resembled injuries of the intervertebral disc which proved to be due to penetrating ulcers of the posterior wall of the duodenum. Two of these had been explored as intervertebral disc suspects. The fact that rupture of the duo-

denum is often precipitated by trauma makes it difficult to differentiate them from spinal lesions.

HOWARD E. SNYDER (Winfield, Kan.): I should like to add to the discussion of the first two papers further remarks on the thoracico-abdominal approach on the right side.

I want to congratulate both of the men who have used it in the management of rupture of the liver. I should like to point out that it is occasionally useful in the gunshot wound and the thoracico-abdominal wound on the right side, and that surprisingly good exposure can be obtained in the right upper quadrant of the abdomen when the thoracic incision is carried only a few inches through the abdominal wall.

I recall one case in which the diaphragm and liver were perforated, the shell fragment lodging posterior to the duodenum. The thoracico-abdominal wound was taken care of, the fragment removed and the wound in the duodenum closed very satisfactorily through such an incision.

I think a point was brought out which is a very good one; that is, the location of the incision should depend upon the injury and that can often be very nicely determined in a penetrating wound where a shell fragment remains or in a perforating wound in which there are both wounds of entrance and wounds of exit.

The other point I should like to discuss is the matter of drainage. It was always my belief that a liver wound should be drained; and, a further point of importance, that when the liver wound was part of a thoracico-abdominal wound, the diaphragm should always be securely closed, preferably with non-absorbable sutures. Also, drainage should be carried beneath the diaphragm to avoid the development of a hepatopleural fistula.

JOHN W. DEVINE, JR. (closing): I would like to thank Doctors Chamberlain and Snyder for their remarks but I will have to differ with my friend, Doctor Chamberlain, on one point.

It was very kind of him to say that he was glad to see the general surgeon opening in the thoracico cage without fear but the profuse hemorrhage that I encountered already had me scared. And how scared can one get? As a matter of fact I have a confession to make on this case. I got into it by accident. The people had called my father but he was operating in another hospital so he sent me.

When I got in and placed the retractor beneath the upper end of the incision and saw what I was dealing with, I was reminded of an old story that I know some of you have heard about a southern surgeon who also had a son. The father had seen this fat colored woman with a large fibroid complicated with pelvic inflammatory disease and scheduled her for operation on a certain Tuesday afternoon. When the time arrived, the father was busy so he sent his son. The old girl did not like that very much but finally, with a great deal of

persuasion, she consented to the son operating. The operation was performed under spinal anesthesia. The situation was getting tense, as any of you know it can if you have ever done any pelvic surgery in the South. The patient, realizing the gravity of the situation, looked up and said, "O Lord, come down here on this earth and help me; and Lord come yourself and don't send your son, 'cause this ain't no place for children!"

ROY H. MOORE, JR. (closing): As to the question of débridement, in the first case that we presented the indication was quite clear. The liver was pulped and fragmented and it was obvious that débridement was necessary. In the second case, which presented a clean extensive cleft of the liver, in my own mind I am still not clear as to how débridement in this type of injury should be carried out, how much liver should be removed and how much of a problem hemostasis would be.

To answer the question on drainage, these patients were drained because of the fear of bile peritonitis; and, as we demonstrated in both cases, the wounds drained bile profusely for many days following the operation.

ELDEN C. WECKESSER (closing): I wish to thank Dr. Coleman and Dr. Siler for their comments and to point out the fact that our cases may have given a little misrepresentation of the problem in that two of them died. Not all patients whose cases are reported in the literature die by any means.

I think that the amount of small bowel that can be successfully removed, not interfering with the nutrition of the patient, is a very variable thing. Even though usually 30 to 50 per cent may be the limit, there are patients that will tolerate a very extensive resection. Dr. Siler's patient had only 18 inches of jejunum remaining. I think that is a practical point we should remember; and when we come across these very extensive cases, we should go ahead and resect them in the hope that they might fit into the category such as Dr. Siler's case.

I was interested in Dr. Sanders' remarks regarding tween-80. I am glad that he had better results than we did. I would mention one thing: In two cases in which we used it, there was a drop in white

count and that is something to watch for in further use of the drug.

VINTON E. SILER (closing): I would like to thank all those who participated in the discussion.

To answer Dr. Johnston's question, I agree that one may see air any place in the retroperitoneal space from rupture of the duodenum due to trauma. As pointed out by Sperling and Rigler in 1937, the air usually localizes to the retroperitoneal spaces in the right gutter. They stressed particularly that when one sees air about the right kidney, this diagnosis should be considered. I think there is no limit to where air may go or even the amount of air that may be present. Therefore, one may see small bubbles of air in any spot and flat and upright roentgenograms of the abdomen should always be taken.

With respect to Dr. Sanders' question, I did not have time to discuss the anatomy of the duodenum but we all know that it is a retroperitoneal organ and one part of the gastrointestinal tract which is subjected to fracture. The first portion is free but the second portion, of course, where the papilla Vater empties into the duodenum, is not so fixed. However, as one approaches the third and fourth portions which traverse the spinal column, the fixation becomes more marked.

In the cases that I have reviewed in this paper the location of rupture has been the junction of the second and third portions and also the third portion itself; occasionally there are reports of rupture of the fourth portion which, of course, is the most difficult to approach surgically.

With regard to injury of the common duct I would say that as one mobilizes the duodenum to the left, one can visualize the duodenal and pancreatic portions of the common duct. I see no reason to extend the incision further into the duodenum and explore the common duct from the interior of this organ. I think you can visualize it adequately on the outside.

With regard to Dr. Mayfield's remarks I agree that the pain may be posterior. We have stressed that point in the paper.



# INTRA-ARTERIAL BLOOD TRANSFUSION\*

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ONE of the most important considerations in the prevention of shock or the treatment of circulatory collapse is appraisal of the disparity between vascular volume and capacity of the vascular system. Certain clinical manifestations, especially an increase in the pulse rate and peripheral vasoconstriction, are important signs in the early stages before a drop in blood pressure occurs, yet there are many conditions under which the vascular volume has decreased to a dangerous level even though blood pressure may be normal. Laboratory procedures such as hematocrit and hemoglobin determinations, while of value in appraising the degree of hemoconcentration in plasma loss or the degree of hemodilution early in hemorrhage, are but milestones in a rapidly changing syndrome. Because of the difficulties encountered in gaining an estimate of the degree of depletion of the vascular volume, work on the intra-arterial administration of blood was begun in 1939. The first patients were treated by the author with intra-arterial replacement in 1939 and 1940.

Intra-arterial blood replacement is based on Pascal's principle, stated as follows, "The increase in pressure on any portion of a confined liquid is transmitted unchanged to all parts of the liquid." Pascal's law applies when pressure is exerted to a confined liquid in a receptacle. A variation occurs in the vascular tree in that the pressure within the arterial system at points distant from the site of injection will be diminished, though slightly, due only to the friction loss against vessel walls. This difference is not considered to be significant. It follows therefore that maintenance of a systolic blood pressure of 120 within the radial artery will result in the maintenance of a systolic blood pressure of approximately 120 throughout the entire arterial tree. If a reservoir containing blood is attached by needle or cannula directed toward the heart to a major artery and the height of the reservoir is adjusted so that the pressure head is equal to the current blood pressure, blood will neither run into the radial artery nor be discharged from the patient into

the reservoir. Vasoconstriction may suffice to maintain a normal blood pressure even though vascular volume may be reduced. As vasoconstriction is released blood will be delivered from the reservoir to maintain the blood pressure. Should hemorrhage occur, blood will be supplied from the reservoir to maintain normal blood pressure, the rate of flow from the reservoir being approximately equal to the rate of loss from hemorrhage. A pronounced fall in blood pressure occurs in the presence of coronary vessel infarction. The openings of the coronary vessels are distal to the aortic cusps. Maintenance of adequate blood pressure levels within the aorta by the administration of blood into the arterial tree will perfuse undamaged coronary vessels. In cases of coarctation of the aorta frictional loss of pressure along the walls of numerous small anastomotic vessels results in a lowered blood pressure distal to the constricted aortic segment. At operation after the constricted segment has been excised and an anastomosis has been performed, removal of the aortic clamps may result in a dangerous drop in blood pressure. This hazard may be overcome by administration of blood into the femoral artery in an amount which will ensure a blood pressure in the distal segment equal to that in the proximal segment.

Kohlstaedt and Page<sup>1</sup> in 1943 first demonstrated the value of intra-arterial blood replacement in hemorrhagic hypotension. They found that the removal of 3.3 to 5.9 per cent body weight of blood from dogs was uniformly fatal. Following a sustained hypotension, the intra-arterial administration of all the blood removed resulted in survival of eleven of twelve animals. Under similar conditions the intravenous administration of all the blood removed resulted in survival of six of seven animals. Most importantly, intra-arterial administration of only one-half of the blood withdrawn to produce hypotension resulted in the recovery of fifteen of twenty animals. Only six of twenty animals recovered when the intravenous route was chosen. In 1946 Page<sup>2</sup> reported that intra-arterial blood replacement was advantageous

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in that perfusion of the coronary arteries was accomplished and that deep breathing started soon after intra-arterial blood infusion. He noted further that blood volume could be restored by this route and that latent hemorrhage could be detected early.

Gardner<sup>3</sup> in 1946 withdrew blood to produce controlled hypotension when serious bleeding might be expected or encountered. During intracranial operations a sufficient amount of blood was withdrawn from an artery to reduce blood pressure and the blood was replaced after the hazardous steps had been passed. This same principle was applied by Love<sup>4</sup> and his associates in 1948 during the removal of an intracranial lesion, with a successful outcome. Shaffer<sup>5</sup> utilized the femoral artery for blood replacement in cases of vascular collapse. Kay and Hacker<sup>6</sup> administered blood into the ascending aorta in a case of circulatory collapse due to transection of the internal mammary artery.

By 1948 intra-arterial blood replacement was being practiced in several clinics. Glasser and Page<sup>7</sup> found that intra-arterial blood administration was an excellent method of resuscitation. Thirty-nine animals subjected to hemorrhagic shock were further bled until breathing stopped for an average of two to eight minutes and the heart stopped beating for two minutes. Intra-arterial administration of blood resulted in resuscitation of 84 per cent of the animals. Fifty-one per cent lived for an average of ten hours and 33 per cent survived indefinitely. Porter, Sanders and Lockwood<sup>8</sup> emphasized the rate of replacement of blood when massive loss occurs. Recovery occurred in eight patients with severe shock when blood was given intra-arterially. The ability to control blood pressure as a safeguard against shock was reiterated. Robertson, Trinchler and Dennis<sup>9</sup> presented data on the intra-arterial administration of blood in twelve patients in whom dramatic results were obtained in ten.

Blood has been administered by way of the aorta, femoral, dorsalis pedis, brachial and radial arteries. No complications have been reported in the nature of damage to the arteries as a result of insertion of the needle. Ligation has been practiced in some clinics when the radial artery has been used. It is cautioned that should a complication occur necessitating ligation of the femoral or brachial artery, serious gangrene might result. Sacrifice of the radial artery in the presence of anastomotic palmar

arches is not hazardous. Unless an anomaly occurs in which an anastomosis may be absent between the ulnar and radial arteries, utilization of the radial artery may be considered safe provided the period of administration is not prolonged. It is our practice to administer blood by use of the radial artery, recognizing that the centripetal administration results in a perfusion of the arm with blood containing a reduced quantity of oxygen. Pressure at the radial artery should not exceed that of the general circulation for extended periods. It is considered safe to permit the same period of time to elapse as that practiced when operations are done upon the extremity under tourniquet application. Periodically the pressure in the reservoir should be brought to a level equal to or less than the systemic pressure in order that blood with maximum oxygen concentration might perfuse the extremity.

The hazard involved in the administration of blood of low oxygen content within an artery in the distal extremity might be overcome by one or two means, either oxygenation of the transfused blood or the introduction of a catheter into the radial artery of sufficient length to deliver the blood at or near the aortic arch. Attempts to oxygenate blood so far have not been unsuccessful. For example, addition of hydrogen peroxide to drawn blood results in a frothing which reduces the pressure head of the reservoir. The administration of such blood under pressure of air or oxygen is dangerous from the standpoint of air embolism. An apparatus has not been developed which is capable of saturating donor blood with oxygen. The use of intra-arterial catheterization has not been reported to date, yet this seems entirely practical in view of the now commonplace venous catheterizations.

I thought in 1939 that the arterial administration of blood was original with me. So far as I am able to determine, the studies summarized above represent the first application of this method since blood transfusion has become a safe procedure. However, before the days when transfusion was safe, Landois<sup>10</sup> referred to the possibility of infusion by the intravenous route directed toward and away from the heart and the intra-arterial route toward and away from the heart. One practical application of the administration of blood toward the heart by the intra-arterial method was reported by Halstead<sup>11</sup> in 1883. The blood of patients with severe illuminating gas poisoning was removed

from an artery, whipped in the open air and replaced by use of the artery. At this stage of its development arterial administration of blood has been demonstrated to be of value under the following conditions: (1) The rapid replacement of large quantities of blood in cases of severe hemorrhage; (2) the replacement of blood adequate to maintain blood pressure levels in cases of concealed hemorrhage; the amount of blood required to maintain normal blood pressure is found to be approximately equal to the amount being lost; (3) the maintenance of normal blood pressure levels in the presence of impending collapse due to trauma or hemorrhage provides an additional important factor in that surgery may be performed promptly when indicated; this avoids the loss of time required to re-establish a safe blood pressure level before anesthesia or operation; (4) perfusion of patent coronary vessels at a blood pressure of any desired level, in cases of coronary infarction; (5) reduction of blood pressure to any desired level consistent with tissue oxygenation, during the stage of operation in which serious hemorrhage may be expected, with the subsequent return of blood to the circulation after the stage of danger has passed and (6) the production of a blood pressure level in the distal aorta equal to that of the proximal aorta prior to the release of clamps after resection of the aorta in cases of coarctation.

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## DISCUSSION

H. GURTH PRETTY (Montreal, Canada): Col. Seeley's paper has brought forward many important points but there are some other points I would like to bring out with reference to it. I have been very interested in this subject for the past three or four years and have been studying it, mainly from the point of view of what happens to our blood pressure when we are doing thoracico-abdominal sympathectomies for hypertension. I have been trying to work out ways and means that we can use to control blood pressure during this procedure.

I tried intravenous methods, both blood, plasma and saline. Finally, I discontinued that, believing that we were having a great deal of trouble in controlling our right heart mechanism. The point was finally brought to conclusion when a patient was admitted for sympathectomy for hypertension. It had been worked up thoroughly by the medical staff but she was transferred to the surgical service, we frightened her and she had a coronary attack. I refused to operate and we sent her home and watched her for a period of three or four months. The cardiologist said she was then ready for a sympathectomy. I disagreed. I said if she had a coronary attack under normal conditions, she would have another due to hypotension on the operating room table. He would not believe it. So we tossed a coin and I lost; I operated.

The patient went along perfectly well in the operating room but upon return to the ward she had a coronary attack and died. We had a cardiograph taken at death and we still cannot get our cardiologist to read that graph.

What I am coming back to is this, that if we get a hypotensive patient and do not supply the coronary circulation, we are going to get an artificial coronary attack. Therefore, we began experimenting with drugs which would produce a vasoconstriction of the capillaries and the arteries. We came to the conclusion that by using 5 cc. per 500 cc. of glucose saline, 1 per cent of neo-synephrine in the form of a drip, we could maintain a constant blood pressure of 120 and that, I notice, is exactly the thing we are referring to, I believe that if you have no intra-arterial transfusion on hand, the neo-synephrine drip, running constantly, will help you over a lot of your difficulties. As a matter of fact, we are going into that point and are using more and more of it instead of transfusions.

# STUDIES ON SKULL FRACTURE WITH PARTICULAR REFERENCE TO ENGINEERING FACTORS\*

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IT is a well known fact that head injury is a frequent cause of death. Investigations made by Crash Injury Research of Cornell University Medical College show that in survivable airplane crashes head injuries are primarily responsible for death. Head injuries also figure prominently in automobile accidents. Medicine and engineering can definitely contribute to a reduction in the severity of accidental head injury by changes in automobile structural design.

Let us briefly consider a few automobile accident statistics. Bodily injuries occurred in a little over 10 per cent of the 45,000 automobile accidents in Detroit during the year 1947 according to the figures furnished by the Accident Prevention Bureau of the City of Detroit. Head, face and craniocerebral injury occurred in approximately 47 per cent of the injured people. The type and severity of the injury received was related to the position or seat occupied by the individual. When the driver had other passengers with him, accidental injury to the driver alone occurred in only 4 per cent of the cases but injuries to the passengers alone occurred in 72 per cent. Both driver and passengers were injured in 24 per cent. (Fig. 1.)

Passengers sitting in the seat next to the driver received injuries most frequently and drivers received the least injuries. Head injuries were most frequently suffered by the passengers sitting next to the driver but body injuries were more common in back seat passengers. (Fig. 2.)

Statistics furnished by the Michigan State Police for the year 1947 show that in rural accidents on the highways head injuries to passengers occurred twice as frequently as to drivers while 67 per cent of all the persons injured received head injuries. It appears that in rural accidents where speeds are greater than in the city head injury is more prevalent. (Fig. 3.)

This brief summary of automobile accident statistics reveals several important factors.

One is that the driver gains considerable protection by holding onto the steering wheel, thus preventing his head from being thrown forward into the windshield or instrument panel. This is particularly true in the lower velocity accidents; but it should be pointed out that at high speeds this same device becomes a lethal weapon since the wheel breaks off and the steering column punctures the driver's chest. It is also apparent that the passenger in the front seat next to the driver receives his head injuries by being thrown forward into the windshield or instrument panel. This occurs in both low and high speed accidents. In view of the large percentage of accidental head injuries it would appear reasonable that the engineer first give his attention to the redesign of windshields and instrument panels.

The total injurious effect upon the organism is, of course, due to the absorption of energy by the head and body. One of the fundamental quantities is the magnitude of the energy and its rate of absorption resulting in definite injury. With these data available, by proper design of windshields, instrument panels, etc., a decrease in the number and severity of injuries in automobile accidents is likely. It is the purpose of this article to present some of this fundamental information. The procedure used to determine the amount of energy necessary to produce fractures of the skull in cadaver heads will be presented.

Parts of our investigations have dealt with the skull itself and have been carried out with the aid of stresscoat. The nature of the deformation (whether primarily due to direct stress or bending) from a blow at right angles from the surface of the skull in any location has been determined by coating the skull inside and out with stresscoat lacquer. The energy of the blow was controlled by dropping the skull of known weight through a measured distance onto a polished steel slab weighing 160 pounds. After the blows were struck, the skulls were

\* From the Wayne University and Grace Hospital, Detroit, Mich.

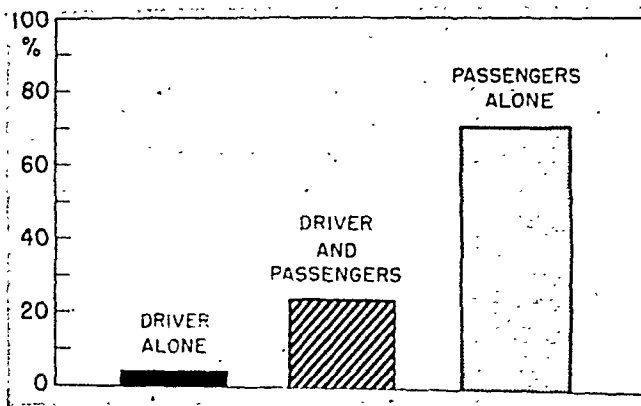


FIG. 1. Comparison of driver and passenger injuries in 289 accidents in Detroit, September, 1947.

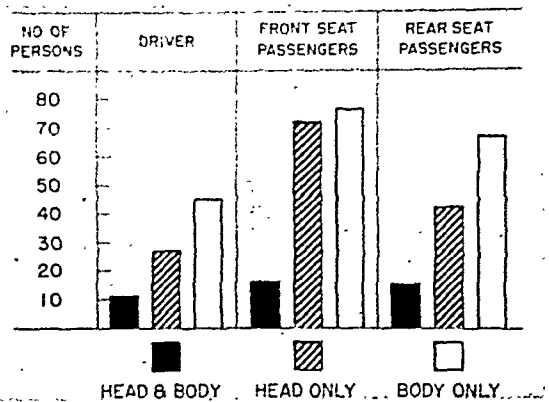


FIG. 2. Comparison of types of injury suffered by occupants of automobiles in 289 accidents in Detroit, September, 1947.

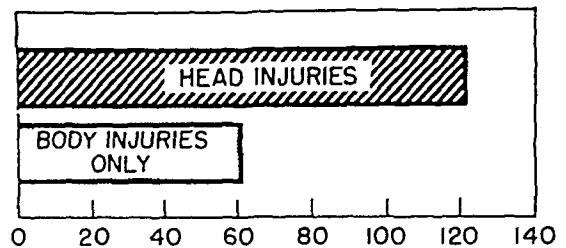
sawed in two on a band saw in order to permit the interior patterns to be developed with red dye etchant and photographs of both the interior and exterior patterns were obtained. The type of interior pattern obtained was remarkably consistent no matter where the blow was struck. Inbending was always indicated directly under the point of impact. If the blows were sufficiently severe, cracks in the lacquer on the interior surface invariably radiated out from the point of impact. The extent of the cracks was always greater in the direction of the maximum radius of curvature, that is, along the flattest portion of the skull. With an adequate blow cracks also formed on the outer surface of the skull dovetailing with the interior pattern and indicating an outbending of the bone.

As a result of the stresscoat tests we find that linear fractures are, in general, initiated on the external surface of the skull due to outbending at a considerable distance from the point of impact. (Figs. 4 and 5.) After initiation the fracture line runs toward the point of impact and also extends in the opposite direction. The fracture line generally reaches the point of impact since after its initial inbending this area rebounds and becomes a region of maximum tensile stress on the external surface as seen from strain gauge studies.

In order to verify the results obtained from the stresscoat tests and to determine the significance, if any, of the hair, scalp and skull contents, impact tests were made on fifty-five completely intact human cadaver heads obtained from the Anatomic Laboratory of Wayne University. Blows were delivered in four positions: mid-frontal, anterior interparietal, mid-occipital and right or left posterior parietal. The results

of these tests confirmed the stresscoat test predictions and indicated that the presence of hair, scalp and skull contents did not alter the position of the resulting fracture. (Fig. 6.) Further confirmation was obtained by examination of clinical fractures by means of x-rays

Types of injury received in 105 automobile accidents in rural Ingham County, Michigan in 1947



Distribution of head injuries to passengers and drivers in 75 automobile accidents in rural Ingham County, Michigan in 1947

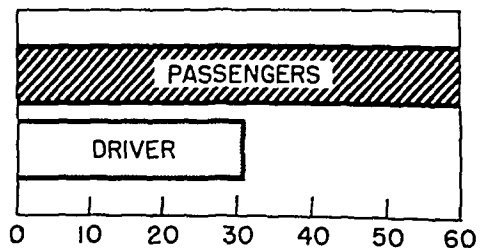


FIG. 3. Injuries in rural accidents, Michigan.

when the position of the blow was definitely known. The point of the blow was indicated by means of a radiopaque wire when the x-ray photograph was made. (Fig. 7.)

While the tests of intact cadaver heads confirmed the predictions of the stresscoat tests regarding location of fractures, they also gave us some information of greater value which may be applied to provide greater safety in engineering



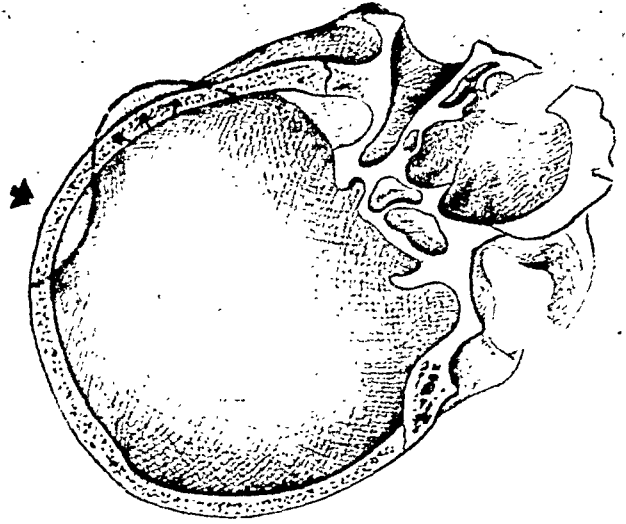


FIG. 4. Stresscoat pattern due to posterior parietal blow indicates region of initiation of fracture.

FIG. 5. Diagrammatic sketch illustrating the inbending of the skull at the point of the blow with simultaneous outbending in the temple region.

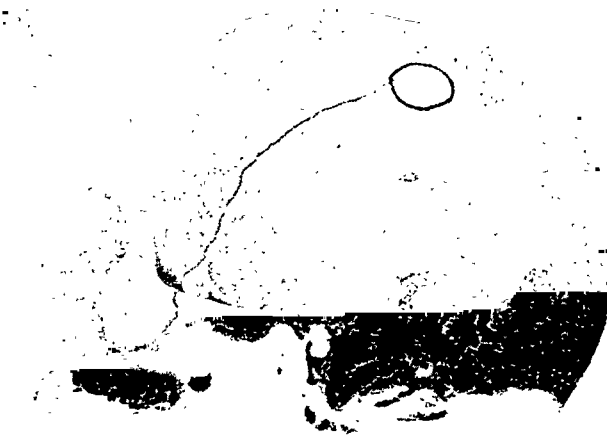


FIG. 6. Fracture obtained in test of intact cadaver and due to posterior parietal blow.



Fig. 7. Clinical x-ray photograph of fracture due to posterior parietal blow.

design. This information is the amount of energy and its time of absorption required to fracture the human skull. Since the weight of each head was obtained (weights varied from 7.3 to 14.6 pounds) and the distance through which it was dropped onto a heavy steel slab was measured, the energy absorbed by the head was easily determined. (Tables I to IV.)

One of the surprising results of these tests of fifty-five cadaver heads is the fact that after enough energy has been absorbed to produce a single line fracture, very little more is required for multiple fractures and complete destruction of the skull. While this might reasonably have been deduced by giving a little thought to

the problem, it was a matter that had not previously been considered.

Energy requirements for the production of a single fracture with blows in four different positions varied from 400 to 900 inch pounds while in one case fracture could not be produced with an application of over 1,000 inch pounds of energy. The difference in the average amount of energy required for fracture with blows in various positions did not appear to be of importance in view of the large variations in energy requirements in any one position. The average energy necessary to produce a single linear fracture with blows in the frontal midline region was 571 inch pounds; in the back midline

region, 517 inch pounds; in the top midline region, 710 inch pounds and in the region above the ear on either side, 615 inch pounds; but the produce single linear fracture. Due to the small number of heads tested, the averages obtained for each position are obviously not

TABLE I  
EXPERIMENTAL SKULL FRACTURE, MID-FRONTAL DECELERATION IMPACT

No.	Energy in Lb.	Scalp Thickness (mm.)	Weight as Dropped (lb.)	Weight Dry (lb.)	Distance Dropped (in.)	Velocity of Impact (ft./sec.)	Race	Fracture*
43	415	4	10.38	1.23	40	14.7	W	II
44	425	4	10.63	1.20	40	14.7	W	I
36	484	5	11.0	1.48	44	15.4	W	I
39	556	5	12.63	2.18	44	15.4	C	II
4	803	4	14.38	1.64	56	17.4	W	I
41	496	5	12.38	1.38	40	14.7	W	III
40	420	3	10.0	1.11	42	15.1	W	III
42	440	3	11.0	1.34	40	14.7	W	III
35	465	4	11.63	1.28	40	14.7	W	III
38	497	7	14.63	2.20	34	13.5	W	III

\* Fracture numbers:

I, single linear fracture

II, two linear fractures

III, stellate fractures

TABLE II  
EXPERIMENTAL SKULL FRACTURE ANTERIOR INTERPARIETAL DECELERATION IMPACT

No.	Energy in Lb.	Scalp Thickness (mm.)	Weight as Dropped (lb.)	Weight Dry (lb.)	Distance Dropped (in.)	Velocity of Impact (ft./sec.)	Race	Fracture*
17	608	6	14.13	1.78	43	15.2	W	I
13	633	5	11.5	1.60	55	17.2	Filipino	I
6	699	4	10.13	1.33	69	19.3	W	I
5	845	4	12.25	...	69	19.3	C	II
12	851	6	10.38	1.89	82	21.0	C	II
20	902	6	11.0	1.69	82	21.0	W	I
9	630	1½	10.5	1.28	60	18.0	W	II
22	677	2	8.25	1.25	82	21.0	W	III
19	681	4	12.38	1.63	55	17.2	W	III
7	653	4	9.06	1.38	72	19.7	W	III
1	843	4	8.78	1.76	96	22.8	Not obtained	III
21	591	4	8.69	1.15	68	19.1	W	III
15	666	2½	9.25	1.15	72	19.7	W	III
16	667	5	10.75	1.14	62	18.3	C	III
25	686	3	9.94	1.41	70	19.5	W	III
10	704	5	11.0	1.37	64	18.6	W	III
11	707	4	10.88	1.77	65	18.8	C	III

\* Fracture numbers:

I, single linear fracture

II, two linear fractures

III, stellate fractures

energy necessary for fracture in the mid-frontal midline area alone varied from 425 to 803 inch pounds. The average energies for complete destruction were very close to those required to

significant but the fact that the least energy required for fracture was in the neighborhood of 400 inch pounds for six of the heads tested is of importance.

November, 1949

This large variation in energy requirements from one head to another is due to difference in thickness of scalp and skull, shape of skull and slight change in position of blow. Since fractures of the skull itself have been produced with as little as 40 inch pounds of energy in the

but it is believed that this difference is of the same order of magnitude as that due to variations in the other factors such as scalp thickness. This belief is based on consideration of the occasional accidental fracture sustained in a baseball game when the batter is struck by

TABLE III  
EXPERIMENTAL SKULL FRACTURE OCCIPITAL DECELERATION IMPACT

No.	Energy in Lb.	Scalp Thickness (mm.)	Weight as Dropped (lb.)	Weight Dry (lb.)	Distance Dropped (in.)	Velocity of Impact (ft./sec.)	Race	Fracture*
45	400	5	10.0	1.27	40	14.7	W	III
31	468	8	11.69	1.74	40	14.7	W	II
32	502	6	11.44	1.68	44	15.4	W	I
23	504	7	10.5	1.93	48	16.1	C	II
33	532	8	10.63	1.63	50	16.4	W	I
26	457	3	9.94	1.16	46	15.8	W	II
30	502	6	12.25	1.32	41	14.9	W	II
24	548	4	8.31	1.73	66	18.9	W	II
27	419	3	8.38	1.02	50	16.4	W	III

\* Fracture numbers:

I, single linear fractures

II, two linear fractures

III, stellate fracture

TABLE IV  
EXPERIMENTAL SKULL FRACTURE POSTERIOR PARIETAL DECELERATION IMPACT, RIGHT OR LEFT

No.	Energy in Lb.	Scalp Thickness (mm.)	Weight as Dropped (lb.)	Weight Dry (lb.)	Distance Dropped (in.)	Velocity of Impact (ft./sec.)	Race	Fracture*
48	845	5	11.13	1.87	76	20.2	W	II
47	840	3½	12.0	2.19	70	19.5	W	III
49	584	5	7.3	1.33	80	20.7	W	III
2	907	4	12.6	1.59	72	19.7	Not obtained	III
46	482	4	9.63	1.41	50	16.4	W	III
50	855	7	11.25	1.61	76	20.2	W	III
51	675	4	10.38	1.60	65	18.8	C	II
53	650	4	12.03	2.22	54	17.0	W	I
54	579	4	9.65	1.43	60	18.0	W	I
55	475	2	8.63	1.68	55	17.2	W	II

\* Fracture numbers:

I, single linear fracture

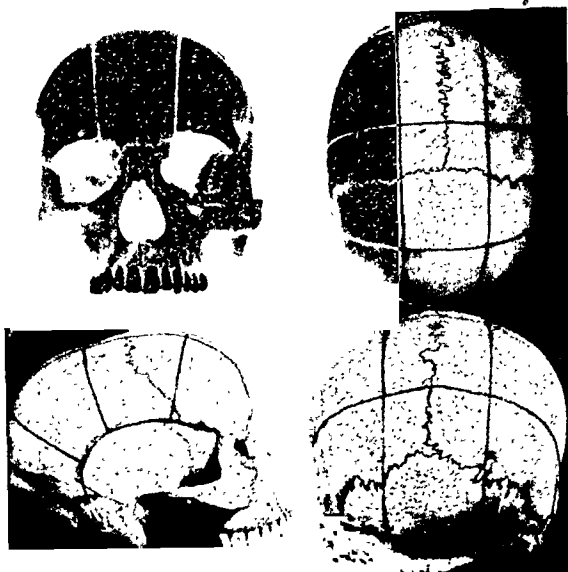
II, two linear fractures

III, stellate fracture

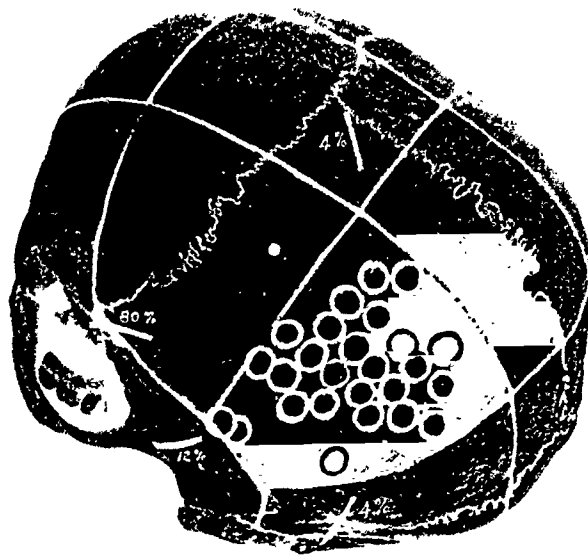
dry skull in contrast to 400 or more inch pounds in the cadaver head, the energy-absorbing capacity of the scalp and its protective function is clearly evident.

That some difference will exist between the amount of energy required to fracture a cadaver head and a living one seems probable

a fast pitch. Using 100 feet per second as the speed of a fast ball (weight 5 ounces) thrown by the pitcher, its kinetic energy will be 580 inch pounds. Some of this energy will go into deforming the ball and accelerating the head; but on the other hand, since the ball is curved instead of a plane surface, somewhat less



8



9

FIG. 8. Photograph of skull showing subdivision of the surface into twelve areas for the study of the effect of blows in each area.

FIG. 9. Composite effect of blows to twenty-five skulls in the left parieto-occipital region showing percentage variation in position of fracture line initiation; fractures will extend to point of blow from regions indicated.

energy should be required to produce fracture since the area of contact is more localized. The fact that this energy falls in the range of values obtained in these tests indicates that the results obtained apply with equal validity to the living human head.

It might be well at this point to note that there is no direct correlation between the severity of cerebral damage and linear skull fracture; that is, a fatality may result due to concussion without any skull fracture occurring. It is also true, however, that skull fracture may occur without any damage to the brain. The fact that in some cases skull fracture was obtained with as little as 400 inch pounds of energy while in another case over 1,000 inch pounds of energy were absorbed by the head without a fracture may be of significance in explaining these phenomena. It is certain that if the accidental input of energy into the human head can be kept below 400 inch pounds, a considerable reduction in fatalities and serious injuries will result.

Both the stresscoat tests and the experimental and clinical fractures have shown that some variation in the position of the fracture is to be expected with a blow in a particular location. This is logical because of variations in the shape and thickness of skulls and slight variations in position of the blow. This variation in position of the fracture line from one skull to another with a blow in a given location appears

to be most pronounced when the skull is struck in the frontal midline region. In some skulls the fracture will appear along the midline above the bridge of the nose. In others it will extend toward the point of impact from the supra-orbital notch above the right or left eye and occasionally it will extend laterally from the temple toward the region of impact.

In order to investigate the degree of this variation a test procedure involving sixty-two skulls was outlined. The top of the head was divided into twelve areas as shown in Figure 8. Each of the sixty-two skulls received a blow in each area thus defined and the stresscoat pattern was obtained. Figure 9 shows an example of the results obtained. This region, the left posterior parietal area, shows about the least variation in the predicted position of the fracture line. The figure includes the results of tests of sixty-two skulls and shows how the position of the blow is varied from skull to skull to cover the entire area.

On the basis of this study it should be possible to predict the position of the fracture line fairly accurately when the location of the blow is known; or if a fracture line is found on the x-ray film, the position of the blow producing it may be determined.

Since the time of absorption of the energy is also an important factor, the electric SR-4 strain gauge was used to obtain this information. The bone was exposed in the temple region of

two heads and SR-4 strain gauges were cemented across the paths of the expected fracture lines as predicted from the stresscoat tests. Blows were to be struck on the side of the head above the ear. When the skull was dropped, it struck a switch fashioned from a piece of brass shimstock on the surface of the steel slab. This switch was connected to one beam of a two-gun cathode ray tube and indicated the initial contact of the head with the steel slab. The other beam was controlled by the strain gauge connected in a simple potentiometer circuit. In one test the fracture occurred at the end of the gauge but in the other we were fortunate enough to have the fracture pass through the center of the gauge, thus opening the circuit. The elapsed time from the instant of

contact of the head with the slab until the skull began to deform in 0.0006 second. The bone itself became deformed during an additional period of 0.0006 second until fracture occurred.

In conclusion we would like to point out that the engineer normally thinks in terms of margin of safety regarding the strength of materials used in structures and machines he designs. We trust that this information regarding the maximum tolerance of the human head to absorption of energy may prove of value to the engineer in his attempts to provide the greatest possible margin of safety against injury to persons when these same structures and machines are subjected to accidental damage.



# ROLE OF THE UPPER CERVICAL ROOTS IN THE PRODUCTION OF PAIN IN THE HEAD

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THE concept that pain in the head and/or face might arise from disease in the neck is not new.<sup>1</sup> Many writers have referred to this possibility.<sup>12,13,16,19,21,23,25,28,33</sup> Similar symptoms, however, have been thought by others to arise from lesions of the autonomic nervous system, for example, the sphenopalatine ganglion,<sup>36-38</sup> the geniculate ganglion,<sup>20</sup> the vidian<sup>39,40</sup> and greater superficial petrosal nerves,<sup>11</sup> the cervical sympathetics, etc.<sup>4-7,10,15,26,27</sup> Vasodilatation due to histamine sensitization of the vascular tree has received wide attention.<sup>17,18</sup> Nevertheless, the etiology of hemicranial pain, migraine, atypical facial neuralgia, histamine cephalgia, the post-concussion syndrome, etc., has remained obscure and the results of therapy disappointing.

The recent clinical investigations of Raney and his associates<sup>29-33</sup> have shown that disorder of the cervical discs may give rise to pain in the head and face. Their attention has been directed to the middle and lower cervical spinal roots. We have been interested in the upper cervical spine and in particular the sensory root of the second cervical nerve.

This article is based on the data of eleven patients who suffered with recurring attacks of severe hemicranial pain in the head and/or face and who have been treated either by (1) avulsion of the greater occipital nerve; (2) intraspinal section of the sensory root of C-2 or (3) section of the sensory roots of C-2 and C-3.

These cases may be divided roughly into two groups, namely, those cases in which symptoms followed definite trauma to the neck and cases in which symptoms of the same character were present without a definite history of initiating trauma. The eight patients whose symptoms followed trauma have been relieved or greatly benefitted by interruption of the upper cervical nerves. Those in which almost identical symptoms were present but without trauma have not been relieved.

It is our purpose in this article to describe the anatomic basis upon which rests the con-

cept that upper cervical root disease might initiate this syndrome, to present the clinical data of these cases and also to present certain data concerning the dermatomes of the upper cervical roots as they have been elicited following operation.

## ANATOMY

The articulations of the upper two cervical vertebrae vary remarkably from the remainder of the movable spine. They connect by two laterally and one centrally placed synovial joints. The first and second cervical nerve roots emerge behind the lateral articular masses. The roots, however, are not protected posteriorly by pedicles and facets which elsewhere in the vertebral column complete the root canal.

Their respective ganglia, instead of occupying intervertebral foramina, lie upon the vertebral arches of the axis and the atlas. These nerves course laterally and slightly upward and soon divide into two primary divisions. The anterior primary ramus of the first cervical root, after emerging from the vertebral canal, passes over the posterior arch of the atlas and curves forward around the lateral aspect of the upper articular process of that vertebra. That of the second passes between the arches of the axis and atlas. The posterior primary ramus of C-2 passes backward and gains access to the soft tissues of the neck after passing between the posterior arches of the axis and atlas.<sup>3</sup>

There is relatively little motion between the atlas and the occipital bone; and since the sensory component of C-1 is so rarely present, it is unlikely that this root often plays a part in the production of symptoms. The joint between the atlas and axis, however, is highly movable and the anterior primary ramus of C-2 is subject to unusual stress, even under normal circumstances. The posterior primary ramus of C-2, which continues into the scalp as the greater occipital nerve, emerges between bony surfaces and is capable of being crushed or traumatized by any movement of the head which would tend to approximate these bony

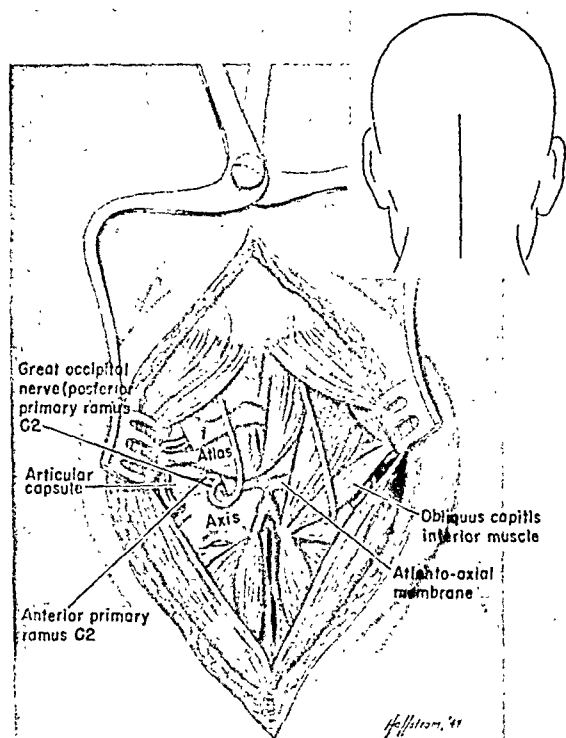


FIG. 1. Artist's drawing of dissection of neck showing relation of the second cervical root to the posterior arches of the first and second cervical vertebrae; muscles denuded on the left side.

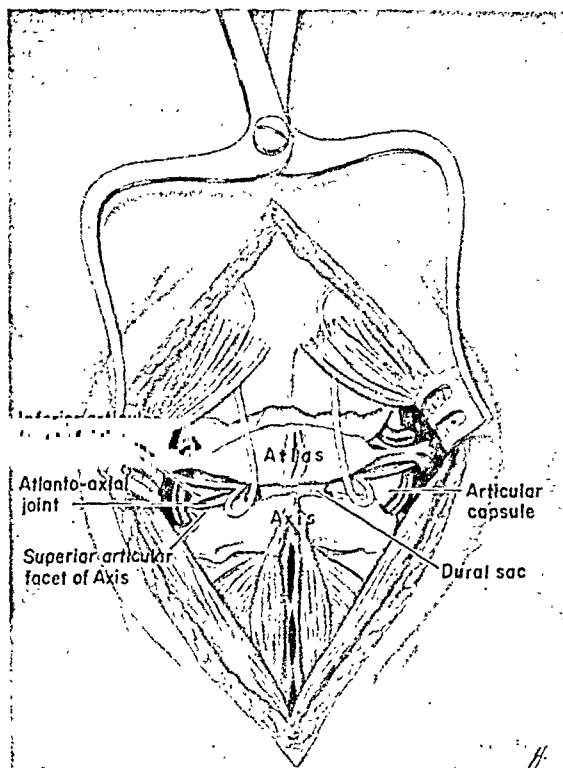


FIG. 2. Relation of the second cervical root to articular facets and rami of first and second cervical vertebrae.

surfaces. Observations of the movements of this joint during manipulation in a cadaver demonstrated that alterations of posture are capable of traumatizing the second cervical nerve.

The third cervical nerve is well protected within its bony canal and seems to be no more vulnerable to injury than any other root.

With rotary motions of the head there is tremendous excursion of the articular facets of the atlanto-axial articulations. The lower atlantal facet on the side to which the face presents slides posteriorly and toward the midline until it is almost off the axial facet and impinges directly on the superior margin of the arch of the axis. If unusual force were applied with the neck in this position or if the nerve ran an aberrant course, crush injury could occur at the point at which the atlantal facet strikes the lamina of the axis. This motion also appears to increase the distance that the anterior primary ramus of C-2 must traverse to leave the spine and if sudden force were applied, stretch injury of the anterior primary ramus of C-2 might occur. On the opposite side, for a distance of approximately 25 mm., from the midline of the axis the arches of the atlas and axis are in contact and actually compress

between them the emerging posterior primary ramus of C-2. In addition the upper articular facet of the axis on this side makes contact with the arch of the atlas and appears to compress the anterior primary ramus. (Figs. 1 to 3.)

This peculiar vulnerability of the second cervical root to trauma comprises the anatomic basis upon which this article rests. Within the normal range of motion of the neck the second cervical nerve probably is not vulnerable to trauma. However, if added force were applied to the neck when it was already at the limit of normal range, damage to this structure could occur. Thereafter, once diseased it is believed that normal motions of the neck are capable of maintaining the nerve in a painful state.

When one considers that the second cervical root supplies sensation to the major portion of the scalp and overlaps considerably into the face area in connection with this peculiar vulnerability to trauma, it seems reasonable to assume that this root may be responsible in certain instances for unilateral head and/or face pain. It was upon this thesis that the cases which comprise the material for this report were investigated and later brought to operation.

The patients with whom we are concerned in

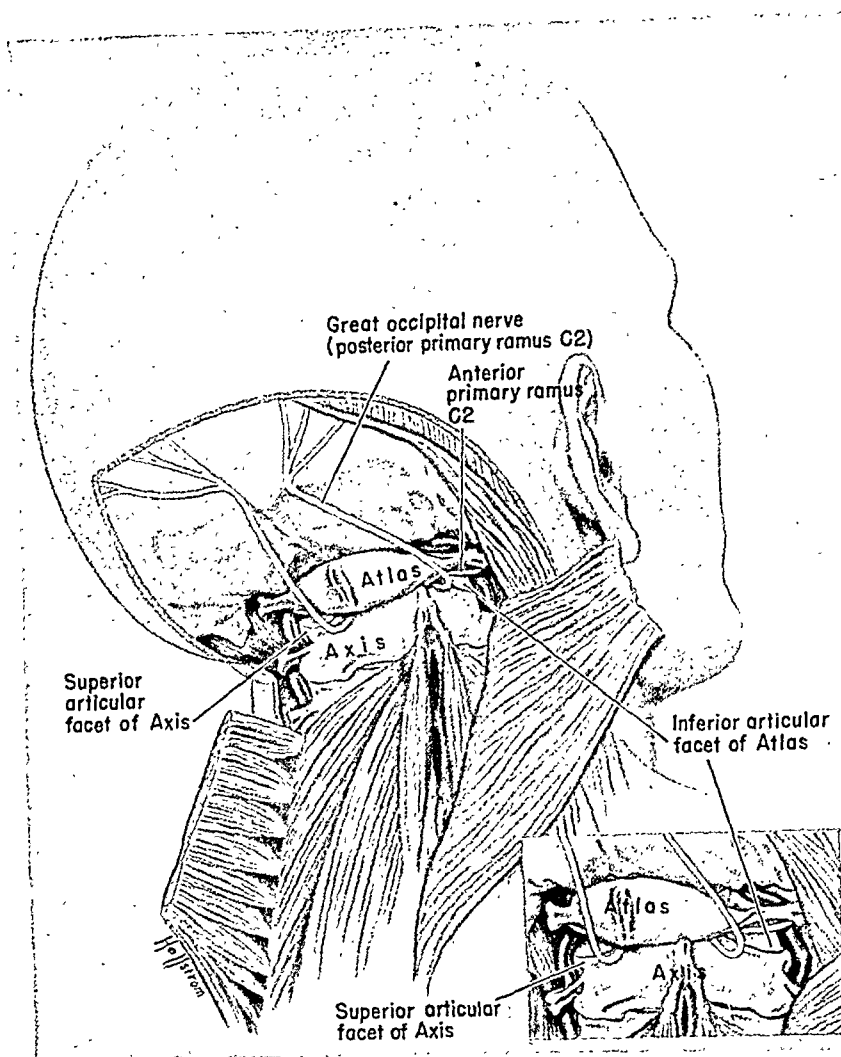


FIG. 3. Altered relationship of second cervical root to the rami and articular facets of the first and second cervical vertebrae with the face rotated to the right and the head extended. (Insert, oblique view of same exposure.)

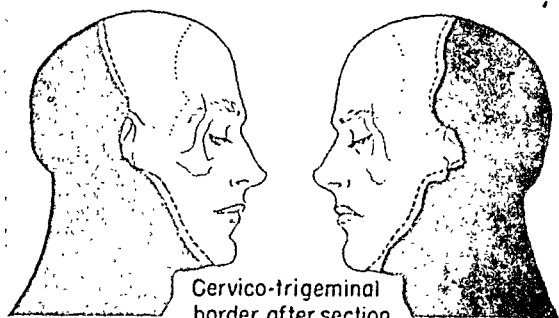
this article without exception presented themselves with the complaint of recurring severe bouts of pain. Usually the bouts involved one side of the head and always the same side. Occasionally, when an attack was most severe, the pain might spread to involve the entire head. For the most part the pain was initiated in the suboccipital region but radiated to the vertex, the temporal area and usually to the area about the eye. The attacks were prone to come suddenly. They were very likely to occur at night and were often associated with tearing of the eye, flushing of the face, alteration of sweat and at times occlusion of the nasal passage on the side involved. In some of them there were lancinating pains into the face, usually about the lower jaw. When the pain occurred about the lower jaw, it was described as superficial. The pain which was referred to

the eye usually was described as a deep, aching pain. In certain patients the pain was referred to the region of the ear but this was less intense than the suboccipital, temporal and eye pain. Many of the patients were conscious of numbness and tingling of the parieto-occipital scalp.

The majority of the patients had been well until they sustained an injury in which the neck was forcibly wrenched. When this group was quizzed, it was brought out that there was more or less constant discomfort in the suboccipital region on the side involved but that they had come to accept this as normal, the severe paroxysms being the issue of chief concern.

Certain of these patients complained of vertigo and a sense of giddiness during the severe paroxysms. Two patients experienced vomiting during the most severe bouts. The





Cervico-trigeminal  
border after section  
of upper cervical roots.  
Foerster, Brain, 1933

FIG. 4.

attacks varied in duration from a few minutes to several days, the majority lasting from two to three hours.

The three patients in this group who gave no history of injury antecedent to their symptoms had not been conscious of the continuous discomfort in the neck.

If the patients were examined during a severe paroxysm of pain, they appeared acutely ill. There always was exquisite tenderness over the course of the greater occipital nerve and over the point of emergence of the second and perhaps the third cervical roots on the side involved. Rotary motions of the neck, particularly maneuvers of hyperextension and rotation of the occiput to the painful side, would exaggerate the symptoms. Examination with the scratch test<sup>22</sup> usually demonstrated sensory loss in the second and perhaps also the third cervical dermatome. Manual traction on the head occasionally would give transient relief. When the second cervical nerve root was anesthetized with procaine, the pain abruptly ceased and infiltration of the region of the greater occipital nerve with procaine would also interrupt an attack but less abruptly and less completely.

If the patients were examined in an interval between attacks, there was pain and tenderness along the course of the greater occipital nerve. If pressure was applied firmly over the point of emergence of the second cervical root, the characteristic pattern of pain was produced for the duration of the pressure. Usually it could be produced by hyperextension of the neck or rotating the occiput to the painful side. The symptoms could not be produced when similar maneuvers were applied to the symptomless side.

In the group of patients whose symptoms had occurred without antecedent trauma, almost identical findings were present but anesthetizing the second cervical root would not interrupt an attack. It tended to lessen the patient's pain but it never could be abolished completely.

### 2nd, 3rd and 4th Cervical Dermatomes

according to Bolk,  
cited by Foerster,  
Brain, 1933

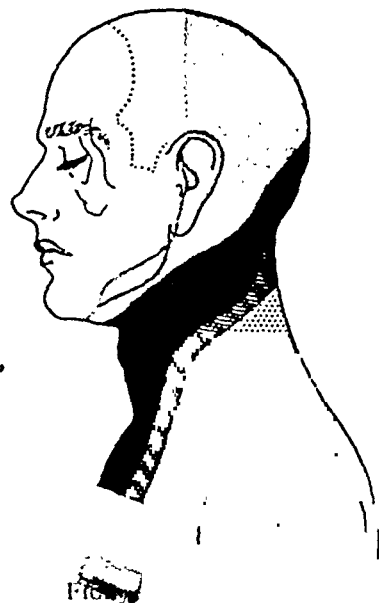


FIG. 5.

The referral of pain from the occipital region into the vertex of the scalp and temporal area when the second cervical root is traumatized is readily understood since this nerve root carries the major sensation to these areas. The referral of pain into the face and the secondary autonomic signs such as lachrimation, obstruction of the nose, etc., are more difficult to explain.

Sherrington's method<sup>34,35</sup> of determining "remaining sensibility" which consisted of cutting three dorsal roots above and below a single root to be studied (in the monkey) indicated extensive overlap of individual dermatomes. Foerster's<sup>8</sup> application of this method in human beings produced the first map of human dermatomes and revealed wide overlap of individual areas. Sherrington's experiments with the macaque<sup>34,35</sup> showed considerable overlap of the trigeminal area by the cervical segments. Zander's<sup>42</sup> anatomic dissections demonstrated terminal filaments of the cervical nerves in all but the central portion of the face, a small area which was designated by Lewy<sup>24</sup> as "the pure trigeminal field." Woolsey, Marshall and Bard<sup>41</sup> have shown in investigation of cortical sensation in the monkey wide overlap of the occipital distribution of the upper cervical nerves by the trigeminal, with supply

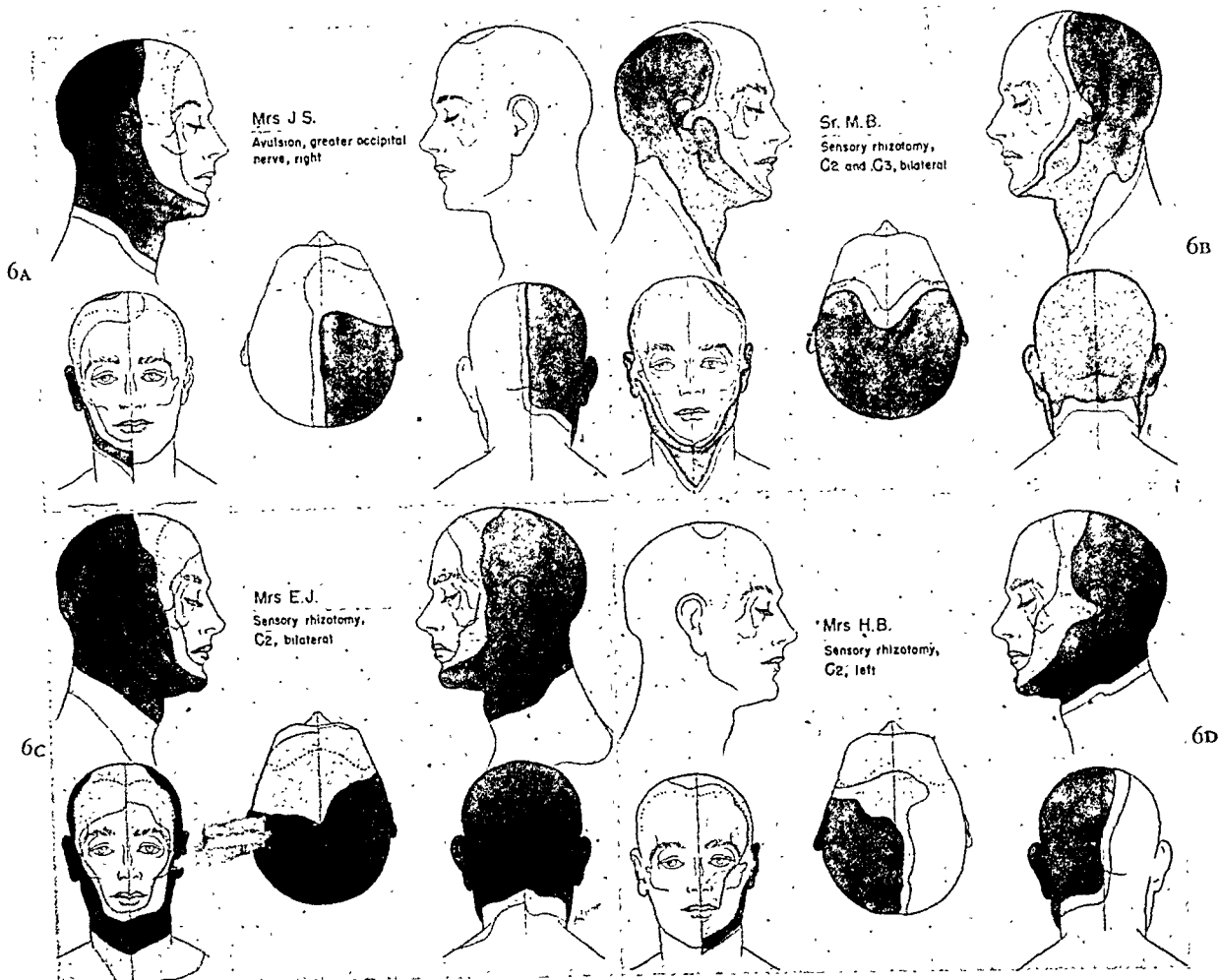


FIG. 6. Areas of sensory loss demonstrated after operation; dark areas, anesthetic except for deep pressure and occasional islands of pain; light areas, diminished pain sensation. A, lower half, after avulsion of greater occipital nerve, right; note that sensory loss extends past midline and along the area inferior to the mandible; B, note relative escape of face in this case as compared to (C) where C-2 was sectioned bilaterally; D, of special interest because of overlap to opposite side and extensive involvement of face area.

to the entire head and in turn the trigeminal overlapped completely by the cervical nerves.

It appears, therefore, that direct anatomic pathways exist by which pain impulses from the cervical region may reach the trigeminal area.

The sensory pattern that followed section of C-2 or section of C-2 and C-3 in our cases demonstrated more extensive overlap of the trigeminal field than Foerster's and Bolk's published studies. (Figs. 4 and 5.)

The residual sensory loss after section of C-2 or C-2 and C-3 shows other peculiarities which are too constant to be dismissed as rare variants. Complete anesthesia was not produced in any of our cases by section of C-2 or C-2 and C-3. The sensory loss was relative and throughout there were numerous islands of pain preservation. Touch was present over the

entire area. There was an overlap to the opposite cervical field in several cases and in some instances it extended for a distance of 3 to 4 cm. (Fig. 6.)

We made numerous attempts to reproduce the patient's symptoms by stimulating nerves that were exposed at operation under local anesthesia. In certain instances the pain was referred to the area in question. This was especially impressive when the greater occipital nerve was avulsed. In two patients whose roots were sectioned intraspinally, stimulation of the second cervical root referred pain to the vertex and the region of the eye. Stimulation of the third cervical root referred pain to the region of the ear and neck. For the most part, however, the results of these examinations were not conclusive.

There are possibly pathways in the periph-

eral as well as within the central nervous system to explain the complaint of pain behind the eye and the secondary autonomic phenomena which are often present.

There are communicating branches from the cervical plexus to the vagus and hypoglossal from both C-1 and C-2; the superior cervical sympathetic ganglion has direct connections with cervical roots 1 to 4.<sup>3</sup>

Corbin and Hinsey<sup>2</sup> have shown by degeneration experiments in cats that the ascending sensory branches of the upper four cervical nerves ascend dorsomedial to the substantia gelatinosa of the upper cervical cord and in a similar position with relation to the spinal tract of the fifth nerve in the medulla, terminating at the level of exit of the glossopharyngeal nerve. Connections are made along the way with the intermediate nucleus of the medulla and with the cuneate nuclei, the fasciculus solitarius and the descending vestibular nucleus and tract.

Foerster<sup>8,9</sup> has demonstrated that stimulation of the distal cut end of a dorsal root produces vasodilatation of the dermatome. This vasodilatation may be due to release of histamine within the tissues. If so, a similar phenomenon could account for the vasodilatation observed clinically and the beneficial influence of intravenous histamine therapy in certain cases.

#### SUMMARY AND CONCLUSION

It is recognized that the follow-up in these cases is too brief to be considered for a final report. It is possible that symptoms may recur in any of those whom we now believe to be well. The striking relief of symptoms which has followed section of the second cervical sensory root in patients with post-traumatic hemicranial pain seems to indicate that trauma to this root may initiate and be responsible for such symptoms. In contrast, there are a group of patients with almost identical complaints whose symptoms did not follow trauma who were not relieved by section of the second cervical root or by avulsion of the greater occipital nerve. It would appear, therefore, that severe hemicranial pain may be initiated by disorder of any of several pathways; and when any one of them is involved, the entire neurovascular tree of one side of the head is affected.

Many phases of this subject require additional investigation, namely, the pathologic condition of the tissues involved and the long-

term results of avulsion of the greater occipital nerve as compared to intraspinal section of the second cervical sensory root; also, the role of the first cervical sensory root, when present, must be determined.

If the follow-up in these cases bears out the present observations, it is hoped that this may enable us to segregate from that large mass of individuals suffering from hemicranial pain a certain number that are due to trauma and are transmitted through the sensory root of the second cervical nerve.

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#### DISCUSSION OF PAPERS BY DRS. GURDJIAN, WEBSTER AND LISSNER, AND HUNTER AND MAYFIELD

JOSEPH E. J. KING (New York, N. Y.): I want to thank Dr. Mayfield and Dr. Gurdjian for their papers. It is the first time I have ever seen such a demonstration of the forces which produce fractures of the skull. All of us are acquainted with the directions in which these fractures run, down toward the middle fossa through the temporal bone from the site of a blow in the parietal region, but I have never seen the mechanics demonstrated so nicely as this morning.

Dr. Mayfield's paper has well repaid me for coming to the Meeting. I recollect well a middle-aged lady whose occipital nerve I have cut and injected three times with relief of pain each time but it always came back. I had a similar experience with a boy at Bellevue Hospital and with still another fellow from Long Island. In each case the pain recurred after having been relieved for several months. Each time the procedure was done under local anesthesia, the nerve with its neuroma being resected and the proximal end injected with alcohol. From Dr. Mayfield's paper I understand that he enters the spinal canal and cuts the dorsal root of C-2. In the future I propose to do the same thing.

KELLOGG SPEED (Chicago, Ill.): I wish to say a word about Dr. Gurdjian's excellent exposition, and compliment him on his persevering work along this line which he has pursued for a number of years.

If we consider the skull as a sheer globe and omit any study or complication connected with the pathologic condition of the brain and its coverings or the cause of deaths from hemorrhage and so on,

as he has done here, we see that his results show that most of the fractures from a diffuse blow occur in the various fossae, in the base of the skull, because the thinnest bone is at these points and that is where the bone will give if it is going to crack.

Skull fractures from the standpoint of mechanics divide themselves, as he said, into two classes, namely, the indented or punctured fracture from the sharp, rapid blow and the linear or radiating fracture from the diffuse or glancing blow. That goes clear back about 100 years to the old irradiation theory of Iran in which he claimed that the diffused blow was spread around the meridional axes of this globular skull and when the force reached the base and the thin part of the bone, that is where the bone gave.

I think we should pay every attention to this exposition because it helps us to decide about symptoms and to give treatment.

LAURIE H. MCKIM (Montreal, Canada): I would like to ask Dr. Mayfield to say something about the very interesting group of cases in which there is unilateral pain which is frequently improved and in many cases cured by cocaineization of the sphenopalatine ganglion. There is such a group of cases and the subject has been interesting to me for a very long time. I have seen at least three such patients who have been temporarily relieved by this procedure and have been permanently relieved by the clearing up of the associated infection of the antrum.

NICHOLAS J. GIANNISTRAS (Cleveland, O.): It is a very strange thing that although I knew that Dr. Mayfield was doing this work, I had never had the opportunity to discuss it with him. The question that I should like to pose so that it would bring the matter to the attention of all concerns the relationship of this work with the whiplash type of injury to the neck that is received when the passenger or the driver of a car is struck from the rear by another automobile. We see this entity very frequently. The patients come in complaining of severe neck and head pain associated with no visible injury and no roentgenographic evidence of any bone disturbance or disruption. Very frequently these patients have been labeled either as neurotic individuals or malingerers. I wonder whether or not we have not made a mistake and misjudged them in view of this excellent presentation.

E. S. GURDJIAN (closing): I think, as Dr. Speed has emphasized, that there is a difference between skull injury and brain injury; and that skull injury *per se* does not mean that there may be a brain injury and vice versa. As you well know, about 20 to 25 per cent of fatal accidents are due to head trauma unassociated with fracture of the skull, the fatal trauma being due to pressure waves produced in the cranial cavity resulting in intrinsic damage

usually around the foramen magnum, causing the death of the individual.

As concerns the previous work on linear skull fracture, it is interesting to review the works of Aran, Felizet, Battle and Bruns. The latter used static loading until one diameter of the skull became shorter than the opposite diameter with resultant fracture. Rowlings, around the turn of the century, also discussed the mechanism of basal skull fracture. It is interesting to note that in all of these studies the position of the initiated fracture is given as being at the point of the blow. Our studies reveal that a linear fracture does not begin at that point. It starts away from the point of impact from outbending of the skull. When the inbended part of the head around the point of impact rebounds, the fracture extends toward the point of impact as well as in the opposite direction. It extends toward the point of impact because although the point of the inbending is initially in compression or pushed in, immediately afterward it rebounds and, as such, represents an area of tearing apart forces; under this circumstance a fracture which has been initiated in that vicinity will tend to go toward that point rather than to the right or the left. We think that the mechanism of linear skull fracture has been properly evaluated with the aid of the stress-coat work.

I enjoyed Dr. Mayfield's paper very much. The problem of hemicrania and the problem of peculiar pains in one-half of the head are seen by neurosurgeons and neurologists very frequently. It is nice that there may be one other method of helping these unfortunate people. As the previous discussor mentioned and as Dr. Mayfield intimated, some of the patients with postconcussion headaches with pain of the top and back of the head may have injured the cervical nerves from the swinging of the head against the neck. It might be interesting to see whether or not blocking of these nerves in some of these cases of postconcussion syndrome might be helpful.

Obviously, this is interesting and good work but one should caution overenthusiasm in the results obtained.

FRANK H. MAYFIELD (closing): I wish to thank each of the discussors.

If I may diverge from my own paper, I would like to commend Doctor Gurdjian for this monumental work. I am sure that because of it our interpretation of the transmission of forces to the brain will be greatly enhanced.

Returning to the discussion of my own paper, I would like to say that I was pleased with Doctor King's comment. We do cut the root intraspinally. It is cut intradurally just proximal to the lamina. It is accomplished by removing half of the lamina of the first cervical vertebra. A dural incision 1 to 2 cm. in length exposes the second cervical root

which can then be picked up on a hook and sectioned. Only the posterior root is divided.

I would like to comment for a moment upon the first cervical sensory root. It is present in less than 10 per cent of patients. We suspect that it may play a part in some of the unexplained pains of the head and face. The skin area that it serves is not understood. We are engaged now in pursuit of the terminus of this root.

Doctor McKim has brought out a very pertinent point, one which I sketched over too rapidly in this paper in the interest of avoiding the gavel. Doctor McKim, there are many disorders which set off hemicranial pain. The sensory supply to the scalp comes from many sources. The chief supply is from the fifth cranial nerve and the second cervical root but apparently the sympathetics from the seventh and ninth cranial nerves also play a part. It would appear that disease of any part of these pathways is capable of initiating a pain syndrome which can involve the entire half of the head. The mechanism of migraine is not understood but it would appear that it is a similar discharge to this. Obviously, however, you cannot cure migraine by cutting any single nerve pathway.

I believe that in the instance which you described there is infection in the nose which initiates a chronic lesion of the sphenopalatine ganglion which from time to time, perhaps under emotional stress, transfers impulses from the autonomic

nervous system into sensory fibers which are then bombarded with stimuli of a potential and frequency greater than those which the sensory nerves usually carry; these produce pain.

It is probable that the cases which are initiated by trauma to the second cervical root will be relatively infrequent but we do believe that it offers a possibility of segregating from this mass of people who suffer with hemicranial pain a few who can be relieved by appropriate therapy.

I have had the experience which you have had of seeing many patients whose pain was relieved after cocainizing the sphenopalatine ganglion. Many of you have seen patients with comparable syndromes relieved by histamine therapy. It would appear that the effect of histamine is a secondary one, secondary to the release of histamine within the tissues by chronic stimulation or irritation of nerves. Perhaps the beneficial effect of histamine therapy is one of intoxication rather than true desensitization.

Doctor Giannestras has raised a point upon which I deliberately did not comment for our information is too immature to permit it. I do not believe many patients who suffer with chronic headache or dizziness after trauma may develop these symptoms as the result of trauma to the second cervical nerve. However, we have not been able to prove this. We will pursue it further and bring it to your attention at a later date.



# SIMULTANEOUS BILATERAL RUPTURE OF THE QUADRICEPS TENDON

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**A**LTHOUGH numerous articles have appeared in the literature describing muscle and tendon tears, relatively few of these refer to involvement of the quadriceps tendon. Furthermore, nearly all of the reported cases of quadriceps tendon rupture are of the unilateral variety while the bilateral type is extremely rare.

The first reported instance of a rupture of the extensor mechanism of the leg dates back to the writings of Galin, 130-201 A. D. However, it was not until 1887 that the first successful operative repair was described by Charles McBurney<sup>1</sup> and only four cases had been proven by operation as late as 1889. It might be mentioned that the mechanism of the extensor apparatus of the leg was apparently not fully understood until Poirier<sup>2</sup> in 1899 clarified the anatomy and pathology of the muscle planes of this region.

No accurate statistics are available as to the total number of reported instances of rupture of the quadriceps apparatus up to this time. However, a comprehensive review of the Bellevue Hospital records for the ten-year period between 1924 and 1934 revealed 322 cases of spontaneous rupture by sudden muscle pull. Of these 318 were fractures of the patella and only four were ruptures of the quadriceps muscle, all of the latter being unilateral. The first proven case of bilateral rupture of quadriceps tendon was that of Fry in 1928; in 1935 Meyeding<sup>3</sup> added one case to the literature as did James<sup>4</sup> in 1938, making a total of three instances reported in the literature to date. In reviewing these three cases it is found that a time interval of from a few minutes to a half hour existed between the ruptures in each instance.

The ruptures of the quadriceps tendon are usually seen after age of fifty, probably a result of weakening of the tendon from obesity and the fibrotic changes of arteriosclerosis, lues, old injury, etc. The actual mechanism of rupture is almost identical in each case. The individual, usually obese, with his knee flexed and his foot

in a fixed position, attempts to save himself from falling by violently contracting his quadriceps tendon. A tear of the tendon takes place; he falls to the ground and then finds that he is unable to extend his leg. The characteristic defect palpable above the patella, the loss of extension, subsequent joint effusion and the typical history usually makes the diagnosis an easy one. Treatment is in all cases surgical repair of the defect in the avulsed tendon.

## CASE REPORT

G. M., a white male, age sixty-seven, was admitted to the Bryn Mawr Hospital on January 18, 1947. He stated that he had been walking on soft gravel while wearing new shoes, had slipped and attempted unsuccessfully to save himself from falling. He then found that he could not arise to a standing position. He suffered no pain at this time. When assisted to his feet he discovered that he could not remain in an upright position unaided and was completely unable to extend either leg forward as in walking. He was then sent to the hospital by ambulance.

Examination revealed an elderly, obese man apparently in no great discomfort. Physical examination was irrelevant except for the lower extremities. Considerable swelling and contusion of each lower thigh and knee existed and several rather extensive abrasions were present about the knees. The patient experienced no pain whatsoever but moderate tenderness was present on palpation of the region just above each patella and characteristic defects in the quadriceps muscles could be readily palpated. Extension of the lower leg was absent bilaterally.

In view of the presence of the contaminated abrasions, operative repair of the avulsed muscles was deferred for forty-eight hours during which time these were treated and an effort was made to diminish the swelling of the involved area. On January 20, 1947, after sterile preparation of both thighs and legs and with the use of continuous novocain spinal anesthesia, operation was performed. A u-shaped incision with convexity downward and extending to the upper margin of the patella was used to expose the involved area. A large quantity of old blood clot was evacuated from each thigh following which the avulsed



FIGS. 1 and 2. Show tears in quadriceps tendons; Figure 1, right leg; Figure 2, left leg.

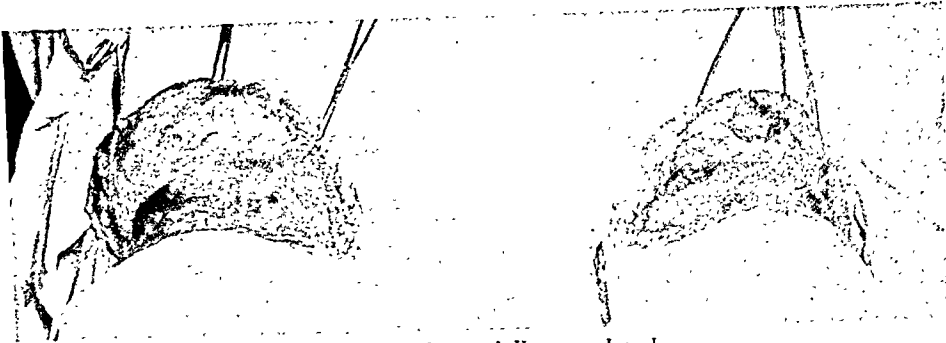
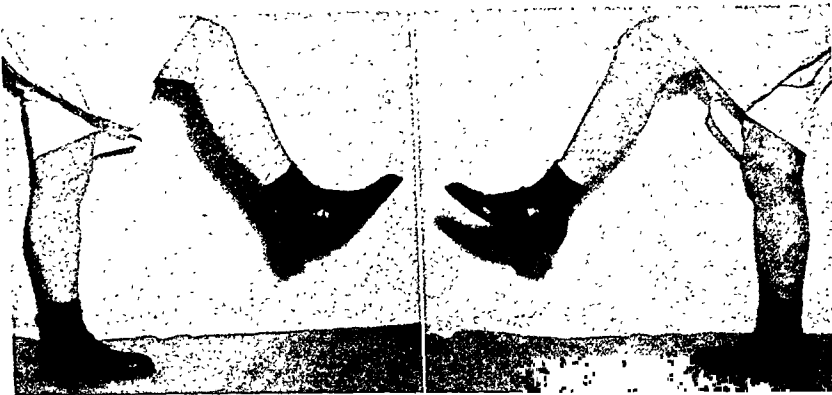


FIG. 3. Repair partially completed.



FIGS. 4 and 5. Show result six months postoperatively.

muscles were clearly visualized. The tear in each muscle had apparently taken place at a point about  $1\frac{1}{2}$  inches above the upper border of each patella. Considerable fraying of the muscle edges existed but no difficulty was experienced in approximating the torn muscles and the repair was effected with interrupted No. 20 black silk mattress sutures. The deep fascia was approximated with interrupted No. 30 silk as was the skin. Immobilization with

the use of plaster casts or splints was not used although partial immobility of the knee joints was obtained with elastic bandages. (Figs. 1 to 5.)

Postoperatively, the patient's course in the hospital was uneventful and both incisions healed by primary intention. Penicillin therapy was begun on admission and continued for five days postoperatively. Guarded active and passive motion of the knee joints was begun on the fourteenth



postoperative day and on February 13th the patient was ambulatory with the use of a cane. The patient left the hospital on February 24, 1947.

#### SUMMARY

1. A brief review of the incidence and of the mechanism of quadriceps rupture is presented.
2. Since no other instance of simultaneous bilateral rupture of the quadriceps tendon could be found in the literature, the case presented was believed to be of interest.

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#### DISCUSSION

EDGAR L. GILCREEST (San Francisco, Calif): Dr. Steiner said that the diagnosis was easy. It is easy if there is complete rupture of a muscle. However, it may be difficult if there is a partial tear or laceration of a muscle. I have seen many of them that had been undiagnosed for months and treated as for a sprain.

I remember one patient in particular who was on horseback. The horse stumbled and fell and the horn of the saddle struck this man's vastus internus, partly tearing it. He was treated for a year conservatively before a diagnosis was made and the muscle repaired.

An interesting point about a tear of a muscle anywhere in the body is that the patient has pain often in the nearest joint. This man complained of pain in his knee and high up in his thigh. Many patients with tears of the long biceps complain of pain in the shoulder and often are treated for bursitis or arthritis and many allied pathologic conditions.

When I became interested in this subject in 1924 and looked up the literature, I was surprised to find such a paucity of articles on the subject. As my interest continued, I finally was able to collect

and to report a hundred cases at the Congress of the American College of Surgeons in Chicago in 1933. A partial tear may be completely disabling. I remember one stevedore who had been under treatment for about two years and was about to be rated as having pre-existing arthritis of the shoulder. He had a most interesting rupture of almost the complete tendon of the long head of the biceps. When I opened his arm, I found that most of the tendon had been ruptured from its attachment on the lip of the glenoid and had turned down in a jack-like fashion to become firmly adherent to the belly of the muscle. Some of the cartilage was attached to the tendon. The tendon was freed and sutured to the coracoid process. This patient secured about a 90 per cent recovery.

In another case the tendon had ruptured and had curled up and was encysted as in a cocoon. There was a fine protective sheath all around it; and when I dissected through that, this tendon sprang out as if released by a spring.

I reported fifteen cases of ruptures of the lower extremity in 1932. Every one of these patients had been injured for many, many months. The partial ruptures are the ones that are difficult to diagnose because, as I said, these patients have pain considerably away from where they had the original hematoma. I think many of them should be given the benefit of early exploration under local anesthesia in order to ascertain whether or not a rupture has occurred. Only by doing this will one prevent a contracture of the muscle with resulting impairment of the function of the limb.

CHARLES F. WOOD (Louisville, Ky.): I think we are all to be congratulated on hearing the report of such an unusual case as this. Obviously, the authors are to be congratulated on their handling of the case as well as their exhaustive search of the literature.

I should like to ask one question: Was any specimen sent to the pathologist or was there any evidence of pre-existing pathologic condition in the tissue at the site of rupture?

It has been my experience (which has been quite limited) that any spontaneous rupture of a tendon, at least of a major tendon such as the quadriceps or the tendon achilles, will show evidence of pre-existing fibrotic or calcifying changes. I would like to ask the authors' views on this matter.

KELVIN MAGILL (Boston, Mass.): Last year at the Boston City Hospital we encountered two cases of quadriceps tears which were unilateral. In both of these cases the tissues at the site of tear showed a great deal of attrition and probably, as the previous doctor just mentioned, the pathologic report, which we did not obtain on these, would verify that impression.

We repaired the tears in both of these cases, using fascia lata strips, interlacing the tissues, and immobilized them in posterior splints for over a

three-week period of time. They both had incomplete extension in approximately two months, as I recall, and were perhaps 15 degrees short of active full extension. This was the best return we could get on our cases in this period of time.

LAURIE H. MCKIM (Montreal, Canada): I would take issue with the gentlemen who have told us that there is always a previous pathologic change in muscle before traumatic rupture. In the last year I have had two cases of rupture of the superficial head of the rectus femoris. They were both in young women under the age of twenty-five; I think one was eighteen and the other was twenty-three. They both occurred in the same way, sprinting. Both women were engaged in athletic competitive races at the time. The muscle was perfectly healthy in every way.

Therefore, I think you may get muscular rupture purely from overstrain without previous pathologic change.

CHILDRESS. I would like to disagree with Dr. Wood on his statement about the pathologic condition pre-existing the rupture and agree with Dr. McKim. I have had four cases of rupture of the tendon achilles which occurred in young men.

My theory is that of Dr. McMaster who has written quite a bit on this in California. He states that the weakest part of the musculotendinous area is at the junction of the muscle and the terminal, at the insertion of the tendon into the bone and also the muscle itself. He makes the statement that the normal tendon will not rupture. That is not true although we have no proof as no slides were made of these cases. But these ruptures occurred in athletes, in basketball particularly, when they

would change their minds, leap up in the air, and as the ball changed direction, would land unexpectedly.

The cause of the tear was a snapping. For example, if you take a fishline, you can pull it forward and not get any result; but if you snap it, it breaks. So I believe in many of these cases you get the tear of a normal tendon. I would like to agree with Dr. McKim on that.

HARRISON L. McLAUGHLIN (New York, N.Y.): Tendon ruptures are biopsied routinely on the Presbyterian Hospital Fracture Service.

To the best of my knowledge there has yet to be a fresh rupture of any tendon, major or minor, in which pathologic sections of the tissues at the site of rupture have not shown an extensive decrease in the collagen in the tendon fibers and a marked loss of nuclei, with enough fibrotic regeneration to suggest, if not prove, that a weak spot antedated the injury.

CHARLES A. STEINER (closing): I would like to thank all the discussers of this paper very much.

Dr. Gilcreest, of course, is perfectly right. In the small partial tears the diagnosis certainly can be overlooked. We were very fortunate in this case in that it was a complete tear on both sides and a very noticeable palpable defect was present. In this case the diagnosis was very easy.

I am afraid, Dr. Wood, that we, too, did not take a pathologic specimen for study. This man was, of course obese and arteriosclerotic. Throughout the literature there seems to be a belief that some pre-existing muscle disease is actually a predisposing cause for this injury.

Again I would like to thank the discussers of this presentation for their interest.



# THE TEXAS CITY DISASTER\*

## A SURVEY OF 3,000 CASUALTIES

VIRGINIA BLOCKER, M.D. AND T. G. BLOCKER, JR., M.D.

*Galveston, Texas*

ON April 16, 1947, at approximately 8:00 A.M., fire was discovered on board the Grandcamp, a French ship (of Liberty type), which lay in the North slip of the Texas City harbor directly alongside Warehouse O (Fig. 1) and across from the Seatrain installation of the Texas City Terminal Railway Company and the Monsanto Chemical Plant. The ship had been loading ammonium nitrate fertilizer for several days and an estimated 2,300 tons had already been placed aboard in 100 pound six-ply paper bags. In addition to the chemical the cargo contained peanuts, machinery, a large amount of sisal twine balls and a small number of boxes containing small arms munitions. Serious efforts at fire-fighting were begun about 8:30, by which time a large number of spectators were gathered in the open area at the west end of the slip and on the dock of the Monsanto warehouse.

At 9:12 A.M. the Grandcamp exploded from detonation of the ammonium nitrate by the fire. The ship itself disintegrated with a tremendous blast, hurling missiles of steel in all directions. Secondary fires in adjacent industrial areas were started by red-hot metal particles and by balls of flaming twine. Meanwhile the force of the explosion had produced a sort of tidal wave about 10 feet in height which rose on to the land from the sides and ends of the slip leaving it momentarily emptied of water, according to several witnesses. The wave was of sufficient strength to float a large hydrochloric acid barge about 100 feet ashore where it came to rest against a pile of wreckage from the ship.

Damage to buildings in the area resulted from the combined effects of blast, missiles and fire. Of the dock warehouses, O was levelled at the outer end where the pier was blown entirely away. In other warehouses roofs were caved in and there was considerable damage from flying debris. At the Monsanto plant, the dock warehouse and southern portion of the polystyrene

building, 350 feet from the explosion, were completely devastated as walls and roof were blasted away. Fire immediately followed. No explosion occurred within the plant but release of hydrocarbon compounds added fuel to flame. The steam plant and power house, which were in direct line of the blast, were levelled completely. In the office and service buildings partition walls were demolished and windows were blown out but there were no fires in these two units. The storeroom, instrument shop and laboratory, although shielded by other structures, were destroyed by blast and fire. The various process units were damaged extensively and tankage fires in these areas burned for over forty-eight hours.

The seatrain installation and the grain elevator, both in the direct line of the blast, were left standing in spite of considerable weakening of these structures from concussion and the effect of missiles. Two water tanks in the area, however, were relatively untouched. A grain conveyor leading from the elevator to Warehouse B was stripped of its siding. The Terminal Railway offices and power house were partially destroyed by concussion; the adjacent machine shop was completely wrecked. Warehouses 1 to 6 behind these structures were riddled by flying debris and their roofs and walls caved in from vertical and horizontal components of the concussion wave. Warehouse 1 was set afire and burned to the ground.

A small, two-story, waterfront cafe located just across the road from the end of the North Slip lay in direct line of the blast and was destroyed utterly. To the west behind this structure the Molasses Company office, a frame building, was entirely destroyed and three metal tanks were badly collapsed and bent.

A number of box cars present within a radius of 1,000 to 1,500 feet from the Grandcamp showed depressed roofs and caved-in sides; several caught fire from incandescent missiles.

Petroleum installations in the explosion area

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were damaged partly by concussion but chiefly by missiles, some of which were responsible for tank fires. A large spheroid at the Richardson Oil Plant, although empty except for a residue of hydrocarbon gases, exploded a few seconds after the ship and may have been responsible

loading at Pier A while the turbine drive was undergoing repairs, had broken loose from its mooring lines at the time of the Grandcamp explosion and drifted across the slip where it came to rest against the Wilson B. Keene, a converted Liberty ship, with one anchor down.

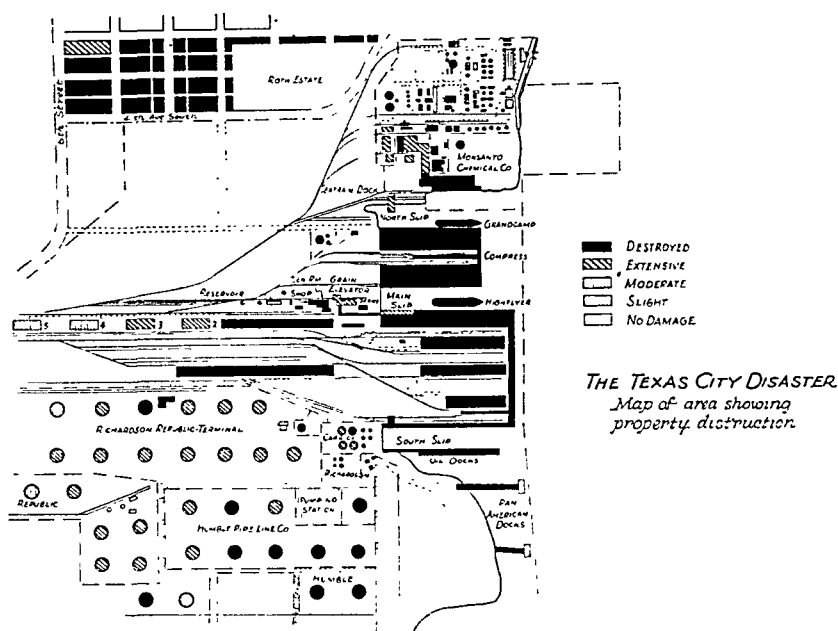


FIG. 1. Map of area showing property destruction. (Reproduced from industrial report of George Armistead, Jr. The Ship Explosions at Texas City, Texas, on April 16 and 17, 1947 and Their Results.)

for the second blast heard and felt by many persons who erroneously attributed it to an explosion in the Monsanto plant proper.

Heavy destruction of residential property resulted in the region to the northwest of the dock area. Several large buildings on the principal business street, approximately 5,000 feet away, collapsed as the walls and roof caved in. Practically all glass windows in the entire community were blown out. Fortunately no fires occurred outside the industrial sections.

#### THE SECOND EXPLOSION

Because of the heavy population of the area at the time of the first explosion, all efforts were immediately concentrated on rescue work; and, as little attention could be given to fire-fighting during the first few hours, a great deal of damage ensued which might have been avoided under less catastrophic circumstances. By the end of the day, however, most of the fires outside the Monsanto plant were under control and it was not until about dusk that fires were reported on board the High Flyer. This ship, a C-2 cargo vessel which had been

In addition to 2,000 tons of bulk sulfur and a quantity of knocked-down box cars the cargo of the High Flyer contained 961 tons of ammonium nitrate fertilizer. Active fire-fighting was begun and an attempt was made about 11:00 P.M. to tow the ship out to sea by means of tug boats with volunteer crews. Although the anchor chain was cut, efforts at dislodging the High Flyer from the Wilson B. Keene were not successful and were abandoned. Soon after 1:00 A.M. fire-fighters noticed that smoke coming from the burning ship showed the same peculiar orange color that had been apparent shortly before the Grandcamp blew up and warning was passed along to all workers to leave the area as quickly as possible. Hence, the second explosion, which occurred at 1:10 A.M. on April 17th, was responsible for relatively few casualties. The blast equalled the earlier one in force and intensity in spite of the fact that the High Flyer contained less than half as much ammonium nitrate as the Grandcamp. It is believed, therefore, that probably only half of the chemical on the Grandcamp, that contained in the Number Four hold only,

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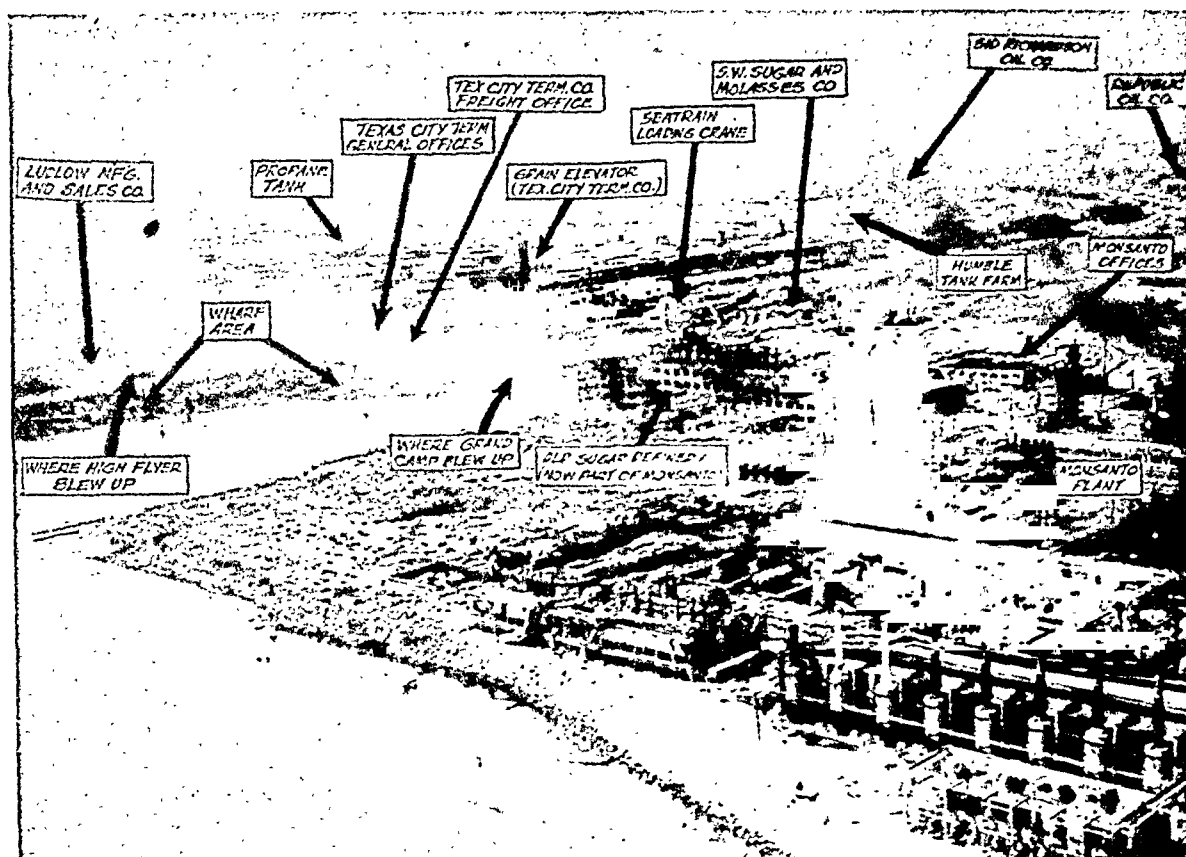


FIG. 2. Aerial view of disaster area made several days after explosions. (Houston Press Staff photograph.)

where the fire originated, was detonated in the first explosion which otherwise might have been of even greater severity and of more disastrous consequence.

With the disintegration of the High Flyer and the aft end of the Wilson B. Keene, against which it had rested, a great, flaming-pink, mushroom-shaped cloud of smoke rose high into the air and incandescent missiles were scattered in all directions. Almost all of the remaining structures in the area with the exception of the grain elevator and the water tanks were wrecked and set afire. In addition a number of large petroleum tanks in the various refineries were fired by incandescent fragments. There was some spread of fire later in one field because of immediate lack of available equipment for proper control. It was estimated that approximately 22 per cent of tankage in the area, mostly crude oil, was damaged or lost. Dock fires resulted from puncture of pipe lines and oil spillage with consequent destruction of wharves, pipeline supports, box cars and other wooden structures. These fires were extinguished for the most part within twenty-four

hours. Fires continued at the Monsanto plant for another day and there was still smouldering among the warehouse ruins almost a week after the disaster. (Fig. 2.)

In an industrial survey of property damage a careful study was made of the distribution of wreckage from the structural parts of the Grandcamp and High Flyer and remnants of their cargoes. In size the fragments ranged from a few ounces to several tons and their location showed the effect of widely varying force and velocity. Within 500 feet there was scarcely a square foot which was not covered with debris; many pieces weighed from 1 to 5 tons. At 1,500 feet, missiles were scattered about 5 feet apart and averaged perhaps 20 pounds with occasional 1 or 2 ton masses of steel plate. One huge fragment weighing 20 tons traveled 2,500 feet to a point where average particles weighed only a few pounds. Beyond this distance scattering of missiles was considerably less uniform and more haphazard. However, there were a number of very large fragments, 1 or 2 tons being reported at 4,500 feet from the center of the blast. Identifiable portions of

the cargo of the Grandcamp were picked up 10,000 feet from the dock area.

The detailed mechanism which caused the detonation of ammonium nitrate by fire is still unknown and attempts to produce explosive effects by experimental means have not been successful. Nevertheless, ammonium nitrate explosions and fires have occurred in the past with considerable property damage and loss of life as a result in some instances. A number of such accidents have been reported in the literature by Dr. C. E. Munroe (*Chem. Met.*, 26: 537, 1922) and R. O. E. Davis (Circular No. 718, U. S. Dept. of Agriculture, March, 1945.) George Armistead, Jr., who prepared an industrial report of the Texas City Disaster (The Ship Explosions at Texas City, Texas, on April 16 and 17, 1947 and Their Results), cites from an independent review of the literature thirteen ammonium nitrate catastrophes in this country and Europe in the past thirty-one years and a previous fourteenth accidental explosion produced in an English dentist's laboratory in 1896. The most serious explosion prior to the Texas City disaster took place at Oppau, Germany, in 1921, at which time more than 500 persons were killed following blasting of caked ammonium nitrate fertilizer by dynamite in order to facilitate handling of the material.

#### STATISTICS

An accurate count of casualties in the Texas City Disaster has been impossible to obtain in spite of the best efforts of all workers. Many persons received first aid only and as the town was almost completely evacuated for several days until danger of continued explosions was considered unlikely, there was considerable dispersion of minor casualties over a wide area. The Red Cross and Galveston County Public Health Nursing Service looked after most of the indigent population and the several thousand members of laborers' families whose homes had been destroyed by the blast. But over a period of several months there arose among this group numerous medical problems which were not associated with the disaster, namely, acute infectious diseases and obstetrical cases, so that their records show some names of persons who were perhaps not in the area or who were not injured on April 16th or 17th. All lists of personnel involved showed inevitable duplication of names from spelling variations, particularly in the case of Latin-American

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workers. Hospital records were begun as quickly as possible by volunteer personnel but many patients were discharged after minor surgery without adequate reports being made. As there was a great deal of shifting about of patients from one institution to another during the first few days, even dependable hospital statistics are not available. Complete check on industrial personnel was hampered by the loss of official records by fire in many cases and by the fact that several companies employed transient day laborers as longshoremen and in other capacities. It is possible that some of these persons, officially listed as missing, were unharmed and simply left town to find other jobs without giving formal notification to any agency. Finally, the spectacle of the fire had attracted a great many sight-seers to the dock area, both on foot and in automobiles from neighboring communities. On these persons no comprehensive count could be made nor could an exact estimate be obtained of the number of men who had driven to the waterfront region to conduct business in person as a result of a general telephone strike which happened to be in effect at the time.

In round numbers there were about 560 persons killed or missing, 800 patients hospitalized and between 3,000 and 4,000 others with less serious injuries. This study is a survey of 3,000 casualties who were within 4,000 feet of the explosion center. In three-fourths of the cases it has been possible to discover the location of individual persons at the time of the explosion. Information has been obtained from the Red Cross, The Bureau of Identification of the Department of Public Safety, hospital and clinic records, personal communication with the various industrial agencies in the disaster area, a review of records of the Texas City Terminal Railway Company and the Monsanto Chemical Company, direct interview with a large number of patients and, finally, from questionnaires distributed to homeless "refugees" quartered at Camp Wallace by the Red Cross and to other persons willing and able to give a coherent account of their experiences.

According to available records there were no survivors among fire-fighters or crewmen who were either on the Grandcamp or standing alongside; no bodies were recovered among this group. (Fig. 3.) One employee of the Texas City Railway Terminal Company who stood on the dock approximately 30 feet from the

ship reported that he first fell into the water as the wharf disintegrated and then was blown 300 feet into the air over Warehouse O onto the tracks on the other side where he landed on his feet. He sustained no loss of consciousness and his injuries consisted of a crushing

missiles in the barrage of flying debris. Almost all of the persons killed or seriously injured in the explosion were within a radius of 1,000 feet from the center of the blast. Less than fifty deaths occurred among patients admitted to hospitals. The majority were killed instantly

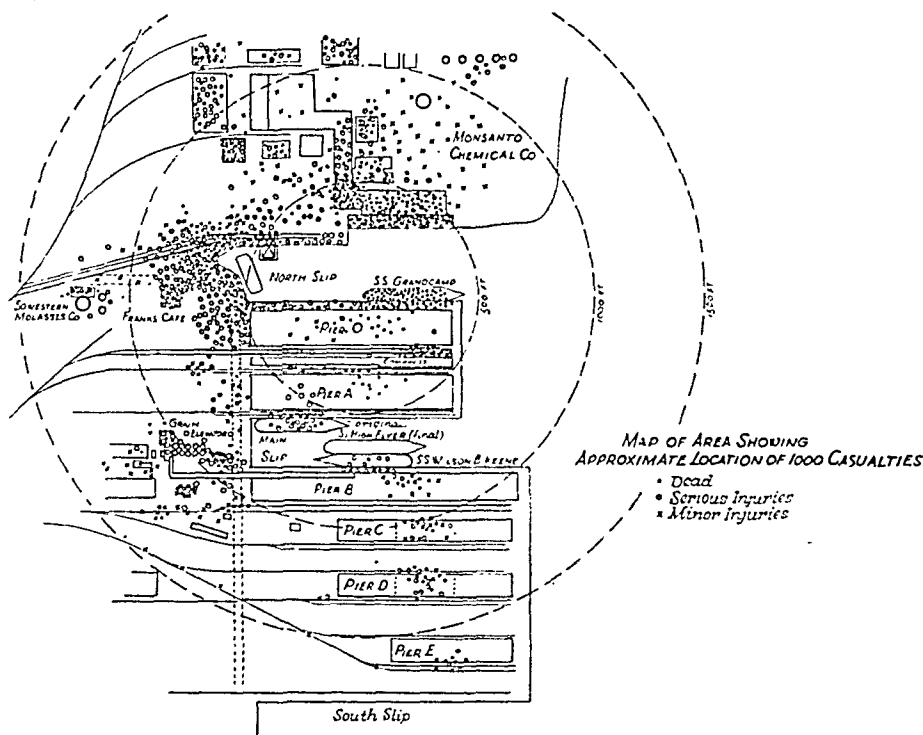


FIG. 3. Map of area showing approximate location of 1,000 casualties.

injury of one foot (which required amputation), perforation of both ear drums and mild head injury. His clothes were all blown off but he had no abrasions or lacerations. His survival must be considered something in the nature of a freak accident since no trace was found of the men with whom he had been standing at the time of the blast.

A colored laborer, standing in the back of a pick-up truck facing north about 50 feet from the ship, was blown horizontally about 500 feet into the open area at the end of the slip. He was momentarily unconscious but had no more serious injuries than fracture of one femur, an avulsion wound over the tendoachilles and perforation of the right ear drum. A total of nine hospitalized casualties reported that they had been watching the fire-fighting from the wharf within a distance of 100 feet from the ship. All of them showed evidence of mild or severe internal blast injury. It must be surmised that their escape from death was due to the fact that they were untouched by larger

by combined effects of blast, dismemberment by flying debris, injury from collapsing buildings, fire or drowning. The "tidal wave" reached the two most heavily populated areas, the open space at the end of the slip and the dock of the Monsanto warehouse. Fatal burns occurred chiefly in the Monsanto plant proper. In all probability most of these casualties were primarily from direct and secondary effects of the explosion. Rescue of bodies was impossible during the height of the fire in the chemical plant and identification of remains was impossible in some cases. In others it was achieved by recognition of keys and other metallic articles found with ashes. It is significant to note that of the patients surveyed there were no deaths which could be attributed to fire and only seven patients with severe burns of any type. Medical problems associated with the Texas City disaster thus differed greatly from those in such catastrophes as the Coconut Grove Fire.

In the immediate area back of the docks

there were in an open field approximately twenty goats, seven or eight cows, several sheep and a mule. As far as could be determined none of these animals were injured in any way except the mule which was killed by a large steel missile.

#### DISPLACEMENT OF PERSONS

A study of displacement of personnel involved in the explosion furnishes interesting proof of the direction of the various blast force components together with the haphazard and unpredictable effects which they produced. Of 461 persons questioned, 27 had no displacement; 256 were knocked down either from concussion or being struck by debris, or both; 86 reported that they were blown horizontally backward for distances which varied from a few feet to several hundred in a few instances. Forty-five were caught by the suction wave and blown horizontally forward in the direction of the blast. Eleven persons were blown vertically in the air for some distance and landed in their approximate former positions. Four were displaced first vertically and then horizontally backward; three first vertically and then horizontally forward; two vertically and laterally; five showed only lateral displacement; two lateral and forward movement.

Of nineteen workmen on ladders and tanks in the industrial area, fourteen were blown to the ground with considerable force and five were blown down and then horizontally backward. The greatest displacement occurred in those persons close to the center of the blast and in those at more remote distances who happened to be within direct line of the blast without intervening protecting buildings.

#### INDIVIDUAL IMPRESSIONS

First-hand descriptions of events showed the variations which might be expected. There was fairly uniform opinion that a peculiar orange-colored smoke was seen shortly before the ship exploded but considerable disagreement as to the number of blasts, whether one, two or even three. It was believed by many that the boat exploded in sections and two distinct blasts a few seconds apart were heard and felt in Galveston, several miles away across the bay. The industrial survey gave evidence, as has been mentioned, that the second blast was due to the setting off of a spheroid at one of the oil plants. Nevertheless, a number of persons re-

ported that they were covered by debris in the first explosion, uncovered in the second; or that they were blown first in one direction and after getting up were knocked down by another blast. Two women reported that they ran from their homes three or more blocks away to the waterfront area on hearing the first blast and were just in time to be struck by debris at the time of the "second explosion."

Persons at some distance from the explosion center experienced sensations similar to those produced by earthquakes, that is, rumbling underfoot or shaking of buildings with accompanying rattling of dishes and furnishings. Those in the immediate area, however, described most vividly the effects of the air blast. An engineer walking away from the docks near Warehouse A was immediately aware of "a soft powerful force" against his body a fraction of a second before he was knocked down and surrounded by a thick black vapor with soft heavy particles falling on his face and body. Others spoke of a "rush of wind." Only a few of the 112 known survivors who were within 500 feet of the Grandcamp remembered hearing the explosion and many within 1,000 feet had no recollection of hearing any sound at all. Among the group of patients who were unconscious for varying periods of time it was noted that the majority recalled feeling the air blast before blacking out even though they sustained moderately severe head injury from flying debris or "blast concussion."

Many workmen and spectators in the area, even inside buildings, had most or all of their clothing blown off by the blast. One colored laborer, unfortunate enough to be caught in the privy back of the waterfront cafe at the precise moment of the explosion, reported "Ah got all mah clothes blowed off but mah underwear and mah shoes, thank de Lawd!" It was surprising that a number of workers whose clothes were literally torn off escaped with only a few scratches and had no demonstrable internal blast injury. Dr. Stafford Warren in personal communication has suggested that this phenomenon might be due to rolling or whirling waves of low pressure produced by friction at the foot of the blast wave as it traveled along the ground.

The "thick black vapor" previously described which filled the waterfront area and rose as a large cloud above Texas City contained huge particles of soot and droplets of





FIG. 4. View showing multiple lacerations of trunk. Case 1.



FIG. 5. Lateral view of head. Case 1.

oil and heavy chemicals. Persons unprotected by buildings had their clothing saturated and were so uniformly covered with the heavy, tarry substance that on admission to hospitals white and negro patients in many instances were indistinguishable. The smoke contained vapors, also, which were extremely irritating to the conjunctival and respiratory mucous membranes although the symptoms produced were only transient in character.

To those disaster victims in the open area at the end of the slip on the Monsanto warehouse dock and as far back as the Molasses Company office where the water rose to a depth of about 4 feet, the so-called tidal wave was perhaps the most frightening experience of all. Members of families or friends standing together to watch the fire were separated by the rush of water; disorientation and confusion added to shock and injury. Many were able to swim to land or cling to floating timbers until the water receded but, undoubtedly, numerous deaths were due primarily to drowning in the case of children and those stunned by debris or the effect of the blast.

#### GENERAL PATTERN OF INJURY

Among the 800 persons admitted for hospitalization certain common features were noted. Most prominent were as follows: first, the multiplicity of lesions in the individual patient; second, the characteristic finding of numerous punctate lacerations, usually from imbedded glass particles and concentrated on the head and extremities; and third, the frequency of fractures of all types. Conspicuously absent were patients with massive avulsion wounds

and with severe burns who did not survive their initial injuries. The majority of patients were in a state of mild shock and responded readily to one or two units of plasma. More than one-third had perforation of one or both ear drums or presented symptoms other than deafness which were indicative of primary blast lesions. The following case histories with accompanying photographs will serve to illustrate typical lesions in the more seriously injured.

#### CASE REPORTS

**CASE I.** W. C. H., a white male, aged twenty-nine, was approximately 500 feet from the Grandcamp in the Monsanto storeroom. He was standing with his left side toward the ship and it was reported that he was blown about 10 feet laterally. He did not hear or feel the blast and was unconscious for about thirty-six hours afterward. He was injured by flying glass and by debris from the building as it collapsed. Injuries sustained were (1) multiple lacerations of the left face, scalp, trunk and extremities with embedded glass fragments covering the entire left side; (2) perforating wound of the left chest posteriorly with mild lung injury; (3) fracture of the left scapula (glenoid cavity); (4) foreign body, left orbit; (5) head injury, moderately severe. (Figs. 4 and 5.)

**CASE II.** R. B., a colored male, aged forty-five, was standing just outside Warehouse O at the time of the explosion with his back toward the ship. He did not hear or feel the blast. He was knocked down and whirled around and was unconscious for a few moments. He was covered by water but managed to wade out without assistance. He complained of blurring of vision, deafness, abdominal and chest pain, headaches and dizziness. His injuries were (1) perforation of both ear drums; (2) contusion of right kidney; (3) acute gastric dilatation (second-



FIG. 6. X-ray of chest showing blast injury of left lung. Case II.

ary); (4) atelectasis and intrapulmonary hemorrhage of left lung; (5) mild concussion; (6) multiple minor lacerations; (7) loss of several teeth; and (8) corneal blast injury? (Fig. 6.)

CASE III. H. B., a white male, aged thirty-six, was walking away from the polystyrene building toward the Monsanto gate at the time of the explosion. He did not hear the blast but felt a rush of wind which knocked him down. He was unconscious and disorientated for about forty-eight hours. In spite of the severity of his injuries he had no complaints suggesting lung or abdominal blast injury. Injuries sustained were (1) fracture of the mandible; (2) penetrating wounds of the mouth; (3) fracture of the skull; (4) perforation of both ear drums; (5) compound fracture of the right radius; (6) intracranial injury, moderately severe; and (7) multiple minor lacerations. (Fig. 7.)

CASE IV. W. P., a white male, aged thirty-six, was working as an engineer in the main office building at Monsanto. When the accident occurred, he was sitting at a desk with his right side turned toward a window a few feet away through which he had been watching the burning ship. He heard and felt the blast which blew him upward out of his chair and backward under a table. He was completely "blinded" by flying glass and was dazed but not unconscious. In addition to other injuries he complained of chest pain and coughed up blood intermittently for a week. His injuries were (1) penetrating wound of the right eye with prolapse requiring evisceration; (2) multiple lacer-



FIG. 7. View of face showing compound fracture of mandible. Case III.

ations of the right side of the face with severance of facial nerve and parotid duct; (3) lacerations of neck, eyelids, left deltoid region and both lower extremities; (4) perforation of right ear drum; and (5) blast injury of lung. (Fig. 8.)

CASE V. N. B., a colored female, aged thirty-seven, was standing out in the open near the Seatrain with her left side turned toward the ship. She felt the blast and saw debris flying through the air in all directions before she was knocked unconscious by a flying missile. When she "came to," she was in water up to her waist and part of her clothes had been blown off. The patient was approximately two months pregnant at the time, and within an hour had an inevitable abortion without complication. Injuries sustained were (1) severe laceration of the left leg; (2) lacerations of the scalp; (3) mild head injury; (4) perforation of the left ear drum; (5) spontaneous abortion; and (6) minor abrasions and contusions. (Fig. 9.)

CASE VI. A. N. D., a white male, aged twenty-one, had just come off fire-fighting duty on the French boat and was standing at the end of the docks facing the burning ship. He was blown a considerable distance backward into the water which flooded the area. He did not lose consciousness for several minutes but was comatose thereafter for forty-eight hours. Convalescence was complicated by urinary infection, a severe infection of the right leg and serum sickness. His injuries



FIG. 8. View showing multiple face lacerations. Case iv.

were (1) basal skull fracture; (2) severe intracranial injury; (3) compound fracture of the mandible; (4) compound fracture of the right tibia; (5) compound fracture of the left tibia and fibula; and (6) urinary retention. (Fig. 10.)

CASE VII. S. R., a colored male, aged thirty-nine, had just come from loading flour on the High Flyer and was standing at the end of Pier O facing the burning ship. When the explosion occurred, he was thrown upward so high that he could see over Warehouse O; he was then blown laterally into the water near the Seatrain installation. He did not lose consciousness and was able to swim to land. Most of his clothes were blown off. Injuries sustained were (1) perforation of both ear drums; (2) severe scalp lacerations; (3) severe laceration of left upper arm with extensive infection; (4) left ulnar paralysis; and (5) laceration of right foot. (Fig. 11.)

Figure 12 shows in graphic form a comparison of the different types of injuries in the entire series of patients studied. Minor lacerations and contusions occurred in a total of 1,452 persons as compared with 332 with major lacerations and 331 with one or more fractures. Head injuries were considered severe in 56 cases and mild in 161 others; these included for the most part the 186 patients who reported a period of unconsciousness ranging from a few



FIG. 9. View showing avulsion wound of left leg. Case v.

seconds to 48 hours. There were 38 severe eye injuries (one patient required evisceration of both eyes); 85 were of milder degree. Five patients reported blurring of vision for several hours but adequate studies were not made to determine whether or not they suffered corneal blast injury. Only 7 serious burns were discovered; the 44 cases of mild burns were for the most part sustained from hot water heaters and stoves rather than from fires set off by incendiary missiles from the Grandcamp. Of interest but not recorded on the chart were eleven cases of delayed or missed menstrual periods and two abortions in women who were within 1,000 feet of the explosion center. A number of other pregnant patients in zones further removed reported no complications.

Perforation of ear drums has been considered as the only single objective sign in the study of pure blast injury. Although most cases were found within a 1,000 foot radius of the Grandcamp, many perforations occurred in persons outside of this area without protection of buildings in the residential zones (2,000 to 4,000 feet), and one case was found almost a mile away in the most distant region covered by the survey. A total of 274 patients with perforation were enumerated, 140 with both drums affected and 134 with only one. Hyperemia of the drum with deafness lasting several days was reported in twelve instances.

Undoubtedly figures for perforation fall short of the actual number which must have occurred. Surprisingly enough, a few patients quite close to the blast center had no ear drum injury. One Terminal Railway official who went virtually unscathed through both explosions in spite of being about 600 or 700 feet from the blast center on each occasion, thought that his ear drums were protected by the fact that he was



FIG. 10. X-ray showing compound fracture of both legs. Case vi.

yelling with his mouth wide open at the moment each ship blew up. It was generally true that within the first zone persons standing with one side toward the blast lost only the ear drum on that side, whereas those further back in the second zone were likely to have perforation of both drums in spite of their position. Patients who were protected from the direct effects of the concussion wave either within buildings or by intervening structures showed as a rule only a small perforation. Many who stood outside in direct line of the ship lost the entire drum on one or both sides.

Evidence of blast injury to the lungs was unfortunately not substantiated by x-ray examination in the majority of cases since early attention was of necessity given to diagnosis of fractures and other conditions amenable to surgical treatment. A total of 155 patients reported either severe pain and tightness in the chest accompanied by shortness of breath or coughing up of blood either on one occasion or for as long as a week. In the absence of fractured ribs or severe chest injury it seems that these symptoms must be presumptive evidence of blast injury to the lungs.

In seventy-four patients within the immediate blast area there were gastrointestinal symptoms, namely, abdominal pain, nausea, vomiting, vomiting of blood or melena. Eight

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FIG. 11. View showing lacerations of left arm before skin grafting. Case vii.

patients had severe injury to the kidneys and bladder; twenty-six others, some of whom were not hospitalized, complained of urinary retention which is a fairly common symptom of blast injury. No attempt has been made to tabulate the number of patients with persistent cerebral symptoms since it is difficult to differentiate psychic and organic factors without thorough study. A great many patients with so-called blast concussion showed no signs of cerebral injury at the time of hospitalization; on the other hand, the majority of those who survived serious head injuries have made most satisfactory recoveries.

In reviewing the orthopedic injuries it has been impossible to secure accurate figures on the number of compound fractures except at the John Sealy Hospital where there were 34 in 133 separate fractures (including those of the skull). It will be noted that fractures of the upper and lower extremity were about equal in number with a large number of rib and skull fractures and eleven instances of fracture of the scapula which gives an indication of the severity of injury in many cases.

TYPES OF INJURY ACCORDING TO ZONES

Three-fourths of the entire group of patients requiring hospitalization were within a radius of 1,000 feet from the explosion center. There were 112 survivors within 500 feet and 418 in the area from 500 to 1,000 feet. Within this

area where families of workmen in the industrial region at the dock had their homes. Here typical injuries were minor lacerations, contusions and abrasions sustained indoors. Surprisingly enough, a great many persons reported forward displacement in this zone, a number

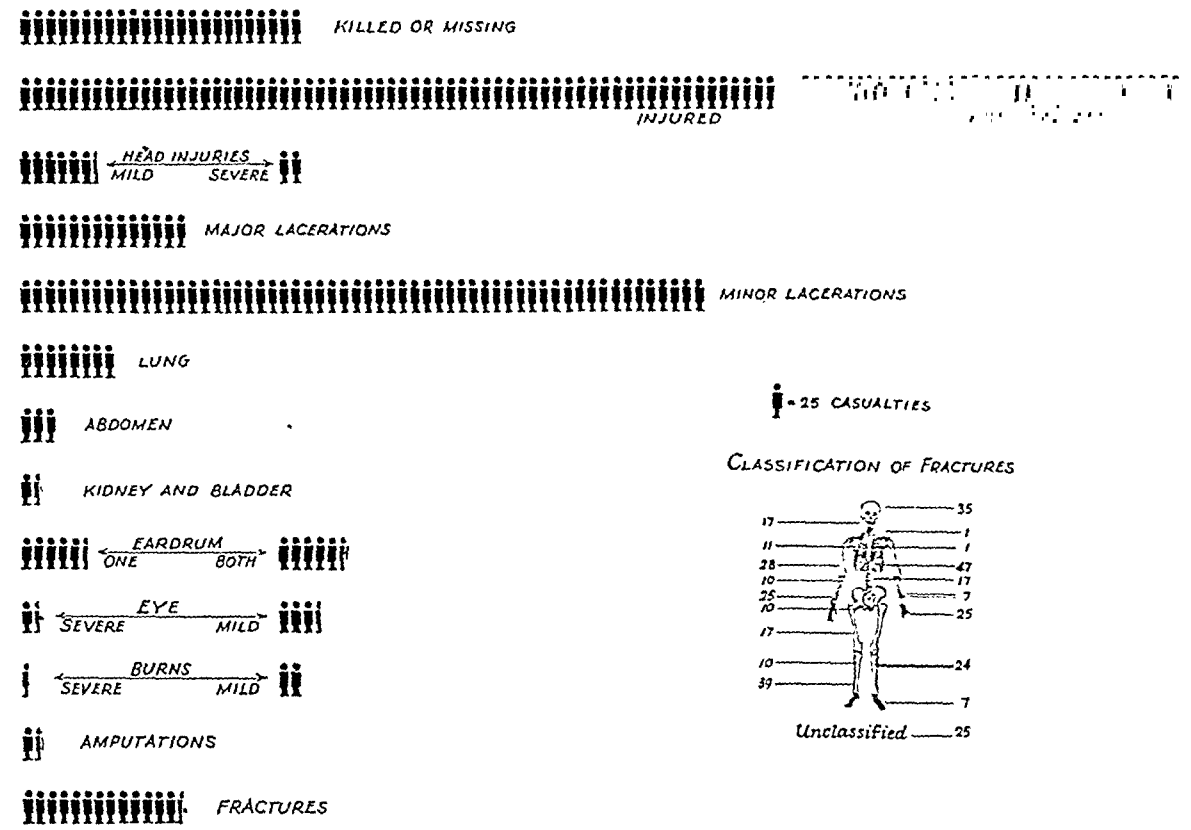


FIG. 12. Shows comparison of various types of injuries. (Reproduced through courtesy of Texas Reports on Biology and Medicine from article by Blocker.)

first zone there were also approximately 250 persons who escaped with no demonstrable injuries. As a general rule those who were out in the open exposed to the barrage of missiles suffered more severe injuries than those inside the buildings which collapsed and they sustained considerably greater damage from effects of the blast itself.

In the second zone (1,000 to 2,000 feet) major injuries were found almost entirely in persons within buildings which disintegrated from the force of the concussion. A fair number of these had perforation of ear drums or symptoms suggesting internal blast injury. An occasional casualty resulted from scattered missiles of steel or other metal.

The third zone (2,000 to 3,000 feet) was heavily populated with approximately 1,400 school children in addition to a large residential

being blown out of doors in the direction of the explosion center. Those who were in direct line of the blast, chiefly in the blocks just northwest of the open space of pasture land behind the Monsanto plant, had the usual signs of blast injury.

Beyond the third zone very little displacement of persons occurred and only an occasional patient reported ear drum perforation.

In the fourth zone (3,000 to 4,000 feet) and beyond casualties showed for the most part only minor injuries, chiefly lacerations from flying glass particles. (Fig. 13.)

*Injuries in the High Flyer Explosion.* As mentioned previously, by the time of the second explosion on April 17th shortly after midnight, most of Texas City had been evacuated and the waterfront area had been cleared except for about thirty fire-fighters and rescue workers.

Furthermore, since warning was given of impending danger, according to the best information available, there was no one within 500 feet of the explosion center. Only one person was reported killed. Seven were hospitalized for serious injuries from falling debris. The remainder escaped with minor lacerations, abrasions, perforation of ear drums, etc.

#### HOSPITAL DEATHS

Of the official list of 563 persons killed or known definitely to be missing following the Texas City explosions, only fifty died following hospitalization. At the John Sealy Hospital there were eighteen deaths. Four patients were dead on admission. The remaining fourteen may be summarized as follows:

- i. Death twenty-four hours after injury, April 16th and 17th
  - Head injury 3
  - Head injury plus compound fracture or traumatic amputation 2
  - Head injury and crushing wound of chest 2
  - Ruptured spleen and head injury 1
  - Penetrating abdominal wounds, severe shock, gas gangrene and anesthesia (death on operating table) 1
- ii. Death two to five days after injury, April 18th to 23rd
  - Head injuries 2
  - Head injury, compound fracture, abdomino-urinary fistula, uremia 1
  - Transverse myelitis, head injury, multiple internal blast injuries 1
- iii. Death one month after injury
  - Massive pulmonary infarcts 1

It was unfortunate that only a few autopsies were performed on patients who died in hospitals and that none were made on the large number of victims brought to the public morgue. Cause of death in many instances was obviously due to dismemberment from flying particles of steel and other debris. In others it was impossible to tell without adequate post-mortem examination whether death was due primarily to the effects of the blast, to drowning, fire, head injury or to a combination of several of these. Autopsies on hospital patients showed in addition to individual injuries and complications typical signs of blast injury, namely, scattered petechiae, small hemorrhages and hyperemia in sections of the brain, heart, lungs, liver, kidneys and gastrointestinal tract. One patient who died forty-eight hours after injury showed acute fatty metamorphosis of the liver and another on the same day had a

considerable amount of diffuse fatty change in this organ.

#### PLAN OF OPERATIONS FOR TREATMENT OF DISASTER VICTIMS

With a catastrophe of such magnitude and in view of imminent danger of further explosions it was only proper that first attention be given to rescue work and to the transportation of injured persons from the immediate disaster scene. First call was for medical and nursing personnel, litters and litter-bearers, ambulances, blankets (for persons whose clothing had been blown off), morphine, plasma and emergency bandages. All first-aid equipment in the industrial plants had been destroyed or contaminated but within a remarkably short time many volunteer workers and a large supply of equipment had been rushed to the area. Chief shortage in equipment was probably of temporary splints for patients with obvious or suspected fractures. Since the only hospital beds available in Texas City were in small, private clinics, it was necessary to transport patients to larger hospitals. About two-thirds of the seriously injured persons were brought to Galveston, the remainder being taken to Houston and to neighboring towns. Three large hospitals in Galveston were immediately alerted for treatment of disaster victims, namely, St. Mary's Infirmary, the county Hospital, the United States Marine Hospital and John Sealy Hospital, the teaching institution of the University of Texas School of Medicine where classes were dismissed and all staff members and medical students reported for duty. In the short interval between news of the disaster and the arrival of the first patients at the John Sealy Hospital a Chief of Operations was appointed to serve with the Superintendent of the Hospital and temporary plans were formulated for the handling of casualties. At the same time all patients who could possibly be dismissed were sent home; others were moved so that entire wards were available for treatment of the injured. Calls were put out through the Red Cross for beds, linen and blankets, blood, penicillin, surgical supplies and nurses. The Commanding General of the Fourth Army sent a Medical Battalion to staff nearby Ft. Crockett and a committee of five to expedite Red Cross requests. Almost immediately hundreds of offers of help began to pour in and it was necessary to make arrangements for answering

calls and telegrams and to designate disposition of supplies as they arrived.

All patients were brought first to the Out-Clinic Building and placed either on mattresses on the floor or in available wheel chairs. A cursory physical examination was made and a

Station Hospital. Others were dismissed with advice to return to the Out-Patient Department for dressings or to their private physicians.

2. Critically injured patients with the exception of those taken immediately to the operating room were sent to shock wards to be made

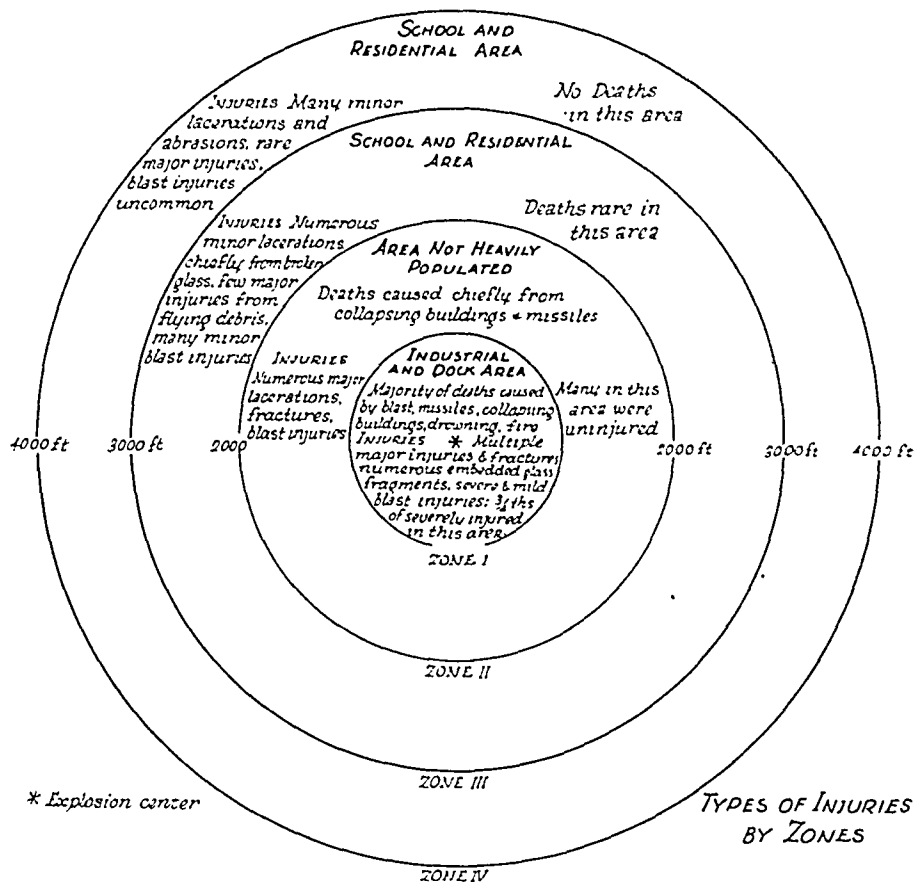


FIG. 13. Types of injuries by zones within 4,000 feet of the explosion center. (Reproduced through courtesy of the Texas Reports on Biology and Medicine from article by Blocker.)

note pinned to each person indicating the name, blood pressure, pulse, list of injuries, amount of morphine and plasma given before admission and a statement of general condition. Plasma was started on all patients in shock except those few with severe hemorrhage who were sent immediately to surgery. The general procedure was as follows:

1. Patients without severe injury were sent to one of a number of minor surgery rooms for cleansing, débridement and suturing of wounds, for the administration of tetanus antitoxin and general examination for evidence of internal injury or overlooked fracture. Those who required further observation were evacuated to a Convalescent Unit set up at the Fort Crockett

ready for surgery. These patients received plasma, blood, intravenous fluids, tetanus antitoxin and penicillin. Oxygen was given as indicated and suitable analgesics were administered under the direction of the anesthesia staff. Following physical examination, patients were seen in consultation by various specialists and emergency laboratory work was taken care of.

3. Meanwhile, patients classified as seriously injured were sent to preoperative wards following cleansing of wounds, application of dressings and x-ray examinations. In the wards they received plasma, blood, intravenous fluids, tetanus antitoxin and penicillin. Specialists were available for consultation. Patients who required only closed reduction of fractures were

referred to cast rooms and then were sent on to postoperative wards.

Ten operating teams were employed at the John Sealy Hospital with three or four men on each, working in shifts for a period of forty-eight hours until all major surgery was completed. As a general rule, no attempt was made at primary closure of large and grossly contaminated wounds except on the face. A staff man was in charge of each operating room and there were three teams of volunteer surgeons. The medical anesthesia staff was in charge of all analgesics, anesthesia, oxygen and blood therapy. A great many calls came in from volunteer surgeons all over the state and country. It would have been necessary to bring in additional operators if casualties had included a large number of severely burned patients. However, for the needs at hand there were at the time approximately seventy-two veterans (formerly military officers) serving as resident doctors in various departments of the hospital and almost without exception these men had had active service overseas or were acquainted with the problems of handling a large number of critically injured patients. Postoperative wards were under the direction of the resident staff of General Surgery with Red Cross and volunteer nurses in addition to regular ward and student nurses. Each ward officer was given a team of medical students who were available for histories, physical examinations, routine laboratory work, dressings and administration of intravenous fluids, gas gangrene antitoxin and chemotherapy. They also served, when necessary, in the capacity of orderlies so that patients could be taken to and from x-ray with dispatch. Each ward was equipped with a messenger system so that the Chief of Operations could keep up at all times with calls for supplies and equipment from the individual units. All patients in the John Sealy Hospital were examined for eye and ear injuries by the Departments of Ophthalmology and Otolaryngology and other specialists were called in as required for treatment of the various complications of patients.

On the morning following the disaster wounds of every patient were inspected for possible complications of gas gangrene and an isolation ward and operating room were set up for débridement of all suspicious wounds. Massive doses of intravenous penicillin and x-ray

therapy were employed in all cases with positive smears for gas-forming organisms.

#### MEDICAL AND SURGICAL COMPLICATIONS

At the John Sealy Hospital there were seven instances of clinical gas gangrene but no deaths could be attributed to the infection. Two patients who died within twenty-four hours after injury from severe head trauma and multiple penetrating abdominal wounds showed evidence of early gas gangrene; a third who died five days after the disaster from head injury and uremia following an abdomino-urinary fistula had evidence of beginning gangrene in the abdominal wall. Of the four patients with clinical gas gangrene symptoms, all made good recovery following vigorous therapy. Two patients had high thigh amputations, one had extensive débridement for a gangrenous lesion of the chest wall and one with gangrene of the upper arm was successfully treated without amputation.

Every patient who had a positive smear for gas-forming organisms received wide débridement of suspicious wounds, x-ray treatment of the area and massive doses of penicillin.

Secondary infection of surgical wounds was not a major problem but did develop in a limited number of cases. Amputation was required in one burn patient following a septic infarct in one of the leg vessels. In one patient amputation was required for dry gangrene resulting from laceration involving a main branch of the femoral artery. In two others with compound fractures amputation was performed following an overwhelming osteomyelitis process. One patient with diabetes had amputation following fracture of the left tibia and fibula with involvement of the knee joint.

Medical problems encountered were chiefly pulmonary. Seven patients had pneumohemothorax following penetrating chest wounds. Twenty had evidence of atelectasis and/or hemorrhage which appeared to be due to blast injury of the lungs. Two patients had closed pneumothorax. In three patients there were large pulmonary infarcts; one of the latter developed approximately a month following injury and was rapidly fatal. In another patient pulmonary embolism was followed by a bronchopleural fistula and massive effusion and infection; following eventual lobectomy, however, he made good recovery. There were four instances of postoperative pneumonia. A few



urinary complications occurred but there were apparently no ill effects following transient retention of urine in a number of cases. One burn patient developed toxic hepatitis as evidenced by jaundice and impairment of liver function. There were two patients with diabetes. One, as has been mentioned, required amputation following compound fracture; the other suffered only minor injuries.

In view of the large doses of tetanus antitoxin and gas gangrene antitoxin which were administered to the majority of the patients, it was anticipated that a large number of serum reactions might be encountered. In the isolation wards either benadryl or pyribenzamine were administered routinely for several days. These drugs were used with good effect on those in whom allergic skin reactions developed. Only a few patients had frank serum sickness; they had complete relief from symptoms following administration of 1,000 cc. of a solution of 0.1 per cent procaine in normal saline.

It was noted on preliminary examination of patients that the majority who were not in shock showed an elevation of blood pressure with the diastolic 95 or above. These cases have been studied and reported by Dr. Arthur Ruskin of the Department of Medicine.<sup>1</sup> There was one instance of paroxysmal tachycardia. One patient with multiple valvular murmurs was suspected of having congenital heart disease; on later examination all murmurs had disappeared and it was believed that signs had been due to toxic dilatation.

Among hospitalized patients at John Sealy only two or three acute psychotic disturbances arose which were thought to be precipitated by the disaster. A number of patients returned to the Out-Patient Department complaining of "concussion" headaches and dizziness. They were evaluated by both Neuro-psychiatric and Otolaryngology Departments and the majority cleared spontaneously within a few months' time. There were remarkably few patients who appeared with the so-called compensation neuroses. Most patients who attributed psychoneurotic complaints to the explosion were found to have been poorly adjusted individuals prior to the disaster.

#### PROBLEMS OF RECONSTRUCTION AND REHABILITATION

The problems of plastic surgery following the Texas City disaster were, in general, of rather

minor nature. It was generally true that patients with severe avulsion wounds did not survive. With the almost negligible number of burn cases, acute problems were limited to lacerations of the face and treatment of mandibular fractures.

Plastic problems which arose during the convalescent and postconvalescent stages included chiefly covering of stumps, flaps and grafts for avulsion wounds of the extremities and revision of scars, particularly on the face. The General Surgical staff was confronted, following treatment of initial injuries, by a large number of patients requiring secondary closure of wounds. One patient was referred to chest surgery for lobectomy and there were a few who required either craniotomy or neurorrhaphy. Orthopedic problems in addition to infection were non-union and care and rehabilitation of patients with severe fractures. There was one instance of paraplegia involving both lower extremities. The Red Cross and Vocational Rehabilitation Agencies were most helpful in assuming responsibility for furnishing prosthetic appliances where indicated and for job retraining in amputation cases.

#### CONCLUSION

The Texas City disaster was the fifteenth of a series of explosions produced as the result of detonation of ammonium nitrate. At the present writing there must be added several additional catastrophes of similar nature and comparable intensity. It is beyond the scope of this paper to discuss the problems of prevention of such calamitous events. From experience in this area, however, and in view of the problematical danger of atomic bombing of large cities, it should certainly be recommended that a comprehensive civilian disaster program be formulated and made available to the entire medical profession for use in widespread emergencies.

A great many doctors, complacently unaware, perhaps, of disaster possibilities, may think that the American Red Cross "takes over" in the event of a major catastrophe. The Red Cross is admirably equipped to handle certain phases of relief and its services in the Texas City area cannot be overestimated. According to agreements with the American Medical Association, however, both organizations recognize that local physicians in a disaster region are primarily responsible for the care of the sick

and injured. It is the duty of the Red Cross to cooperate in supply necessary medical aid and in recruiting nurses and doctors where facilities are inadequate but the Red Cross does not presume to tell the doctor what to do or how to treat his patients.

Although it is desirable for medical disaster committees to be appointed in heavily industrialized communities where explosives and inflammable materials are manufactured or handled, it must be borne in mind that volunteer recruits solicited in advance are often not available in time of need for one reason or another. Furthermore, it is conceivable that a catastrophe may include among its victims all immediate medical personnel so that treatment of large numbers of injured persons may fall upon doctors who are unfamiliar with local conditions and unprepared for the tasks at hand.

A detailed disaster program for physicians should stress, first of all, a plan of organization of medical and hospital facilities to take care of patients efficiently and with dispatch. There is a general tendency for too many persons to be sent to the immediate disaster area with little or no equipment and with no designated authority in charge of first-aid activities. The direction of volunteer workers involves careful consideration if their efforts are to be put to effective use. The appointment of a clerical staff at the very outset of activities is of the utmost value in preventing confusion on every side. The names of victims and all material needed for purposes of record or reference should be arranged in orderly files on index cards and alphabetized for ease in handling. Many workers if left to their own devices will keep important information on small pieces of paper which are likely to be lost or misplaced. Others compile lengthy complicated lists in longhand which are unwieldy and are accessible to only one person at a time.

Proper certification of medical and nursing volunteer workers is extremely important if these persons are to perform duties for which they must assume medicolegal responsibility. Certain unscrupulous individuals are always at hand to exploit disaster victims for their own purposes and much embarrassment may be avoided if credentials are checked in advance. With rapid air transportation it is always possible to import well qualified surgeons and consultants to an area; only in a rare instance is an unskilled person justified in attempting a

difficult operative procedure of emergency nature.

Adequate provision should be made for dealing with the press so that official information comes only from reliable authority. Following the Texas City explosions there were, for example, widespread and fantastic rumors concerning the danger of gas gangrene which was popularly believed to be the result of poison gases and of a highly contagious nature; actually the problem of gas gangrene was a very minor one and a great deal of needless panic might have been avoided.

A disaster program for doctors should include standard methods of treatment of burns and of all types of wounds as well as major medical complications and the use of plasma, blood and antibiotics. It must be emphasized that primary closure of large, heavily contaminated lacerations, no matter how tempting, is ill-advised and potentially a dangerous procedure.

Without a doubt the fact that hospital personnel had had military training and experience in World War II in handling large numbers of casualties was of prime importance in establishing and carrying through an organized plan of treatment of the more seriously injured patients in the Texas City Disaster. To the Army must go credit also for its assistance to the Red Cross in furnishing immediate personnel and supplies of every description from its various stores. Services of all individual physicians in the area were donated without charge for the period from April 16, 1947 to July 1, 1947, and all medical fees collected from insurance companies, the Red Cross and patients themselves were placed in general funds to be allocated either for research projects or for charitable causes. It was generally believed that the victims of the Texas City disaster were handled on the whole with admirable efficiency by local, Army and Red Cross workers with the entire situation a matter of group responsibility.

#### REFERENCE

1. RUSKIN, ARTHUR. Blast hypertension. *Am. J. Med.*, 4: 228, 1948.

#### DISCUSSION

EDGAR L. GILCREEST (San Francisco, Calif.): I should like to ask Dr. Blocker if he would tell us what he would do that he had not done that day, if they had another catastrophe like the one described. (Dr. Blocker answered by reading the concluding paragraphs from his paper which were omitted for lack of time.)

# MARJOLIN'S ULCER\*

## A PREVENTABLE THREAT TO FUNCTION AND LIFE

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THE occurrence of malignant ulcers in cutaneous scars was described by Marjolin in 1828.<sup>1</sup> The scars which produce Marjolin's ulcers are always of long duration and subject to the more or less continuous trauma of tension, friction or weight-bearing. The sources of the scars are varied but burns rank high as a causative agent. While the cutaneous carcinoma which occurs in irradiated cicatrices or in the scars resulting from irradiation is not ordinarily classified as Marjolin's ulcer, the mechanism of production is not far different. Both depend upon the sequence of repeated ulceration and healing in a dense, relatively avascular, collagenous cicatrix covered by thin, unstable epidermis. The scar becomes progressively less vascular until an indolent ulcer appears which never completely epithelizes. In irradiated scars the element of perivascular infiltration which seems to be characteristic of these lesions adds to the ischemia and probably accounts for the more rapid progression of ulceration in such lesions than in those due to other types of trauma.

The duration of the scars before malignant ulceration develops is variable, occurring in from a few years to over half a century. The true Marjolin's ulcer is almost always a squamous cell carcinoma while the carcinoma in an irradiated scar may be either basal or squamous cell. It is impossible to determine the presence of malignant change except by microscopic section. Careful examination of the entire circumference of the ulcer may be necessary to find one small area of squamous cell carcinoma. Gross evidence of induration and irregularity at the margins of the ulcer and a deep necrotic base are suggestive of malignancy but are not conclusive. Regional lymph nodes are rarely involved early. Untreated carcinoma in a scar eventually causes death of the patient but remote metastases are slow to appear. In one of the author's cases which terminated

fatally only regional lymph node metastases were found at autopsy. The slow progress of the neoplasm renders it susceptible of cure with radical surgical excision and skin graft plus local lymph node resection when nodes are involved. Prophylactic node resection is not employed routinely.

Reports from the literature probably do not represent the true incidence of carcinoma in a scar. Among twenty-five carcinomas of the hand reported by Mason,<sup>2</sup> seven were Marjolin's ulcers and eight were due to roentgen dermatitis. Of 239 collected cases reported by Mason, sixty followed trauma other than irradiation. Treves and Pack<sup>3</sup> reported thirty-four cases of carcinoma in burn scars, reviewed the subject in their comprehensive monograph and quoted reports by Baasner<sup>4</sup> of 190 collected cases of scar cancer (thirty-three following burns) and by Durand<sup>5</sup> of ninety cases of degenerated scars, seventy of which followed burns. Treves and Pack reported that at Memorial Hospital from 1917 through 1929 2 per cent of all epidermoid carcinomas originated in skin which had been subjected to thermal injuries and 0.3 per cent of all were basal cell carcinomas. Schrek<sup>6</sup> estimated from an analysis of cases from Pondville and Huntington Memorial Hospitals that 18 per cent of all malignant tumors in the scalp, trunk, legs and arms developed in pre-existing scars of burns, lacerations, surgical operative incisions and ulcerations. Twenty-five cases were reported by Roffo and Gandolpho,<sup>7</sup> fifteen by Paillas and Bonneau<sup>8</sup> and individual cases of malignant tumors occurring in scars have been reported by Halford and Gotshalk,<sup>9</sup> Niedelman,<sup>10</sup> Shore,<sup>11</sup> Robinson,<sup>12</sup> Fleming and Rezek,<sup>13</sup> Danzis and Freedman,<sup>14</sup> Browne<sup>15</sup> and by about twenty other authors in less accessible journals within the past twenty years. No reliable data exists from which the incidence of malignant ulcers in burn scars can be estimated. There is, how-

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FIG. 1. A, Marjolin's ulcer in a burn scar of the leg of twenty-five years' duration; B and C, anterior and medial views of the leg three years after resection and replacement with dermatome grafts; D, the arrow points to a depressed area in the posterior scar which is open to suspicion and may require excision later. Case 1.

ever, some support for the opinion that any scar which is subjected to continuous trauma will eventually become malignant if the patient lives long enough.

#### CASE REPORTS

**CASE I.** D. W., a forty year old male, was burned severely at the age of fifteen years. The burns about the right thigh, knee and leg required more than a year to heal but skin grafts were not employed. After healing was complete, the scars about the knee and popliteal space were so tight that movement was somewhat limited. For five years prior to operation the dense scar in the region of the tibial tubercle (Fig. 1A) had broken down repeatedly and had finally remained open for two years. Examination showed two irregular ulcers on the anterior surface of the lower leg just below the knee. The larger one, 2.5 cm. in diameter, showed irregularly curled, indurated edges and a deep necrotic base. The smaller ulcer was more superficial. There was no significant enlargement of inguinal or femoral lymph nodes. Previous biopsies from the ulcers performed elsewhere had shown no evidence of malignancy.

The areas of ulceration were widely excised together with the bridle-like contracted scars which extended on each side of the popliteal space. With retraction of the relatively normal surrounding skin after removal of the dense scar, a large defect

was created which required 90 square inches of free skin graft to cover (dermatome grafts of .016 inch thickness). Healing was complete within two weeks and the patient resumed normal activity within one month. Function of the involved knee gradually became almost equal to the unaffected one. Three years after operation he remained free from evidence of local recurrence or lymph node involvement. The microscopic section of the larger ulcer showed an area 2 cm. in length about the margin of the ulcer to be the seat of a well differentiated squamous cell carcinoma. (Fig. 1.) The smaller ulcer showed no malignant change.

**CASE II.** B. D., a male, twenty-five years of age, had a chronic ulcer on the anterior surface of the leg below the knee following a severe burn during infancy. The area had been excised elsewhere but the ulcer had recurred. At the time he was seen in consultation he presented a very large area of ragged ulceration about the inferior aspect of the knee joint which obviously extended into the knee joint capsule. (Fig. 2.) Sections confirmed the presence of squamous cell carcinoma. Amputation in mid-thigh and inguinal node dissection were performed elsewhere. No follow-up information on the patient is available.

**CASE III.** S. B., a female, sixty-six years of age, was burned severely on the back at ten years of age. A small area in the mid-lumbar region had never remained completely healed since the time of the burn. Upon examination she showed an area



FIG. 2. A Marjolin's ulcer of about eighteen years' duration in a young man; invasion of the knee joint necessitated amputation. Case II.

of dense cicatrix involving the lumbo-sacral region, with an indolent ulcer 3 cm. in diameter in its center. The surrounding scar was hard and areas of apparent calcification were palpable. No enlarged lymph nodes were palpable in either groin. The entire area was excised and replaced with 64 square inches of free skin graft. Even though the ulcer had been present for over fifty years, microscopic section showed only very early neoplastic changes. Three years after excision she was completely free from symptoms referable to the ulcer and in good health.

CASE IV. H. S., a male, forty-nine years of age, was admitted to the hospital for terminal care, presenting extensive burn scars of the right groin, abdomen and thigh. He had been hospitalized three years earlier because of a chronic ulcer in the burn scar which he had received thirty-five years before. The ulcer together with underlying lymph nodes had been excised and the defective skin grafted. At the time of his second admission the nodes had recurred and massive iliac nodes were palpable also. At autopsy the iliac nodes were extensively involved with poorly differentiated squamous cell carcinoma. No other metastases were found.

CASE V. V. Z., a male, thirty-nine years of age, complained of a draining sinus with ragged edges which had been present since childhood following an operation for osteomyelitis. (Fig. 3.) Roentgenograms showed moth-eaten destruction of the proximal tibia. Sections of margins of the ulcer

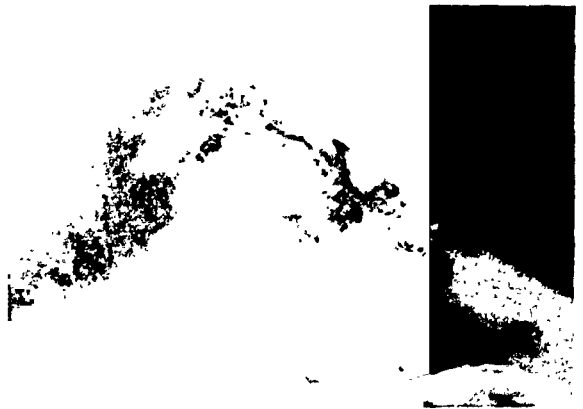


FIG. 3. A Marjolin's ulcer of about thirty years' duration in scars resulting from chronic osteomyelitis; extent of invasion necessitated amputation. Case V.

showed squamous cell carcinoma, unclassified. Mid-thigh amputation resulted in freedom from evidence of recurrence for ten years. Regional lymph nodes were not involved.

CASE VI. S. F., a colored, fifty-six year old female, was seen in consultation presenting a large, irregular ulceration with indurated borders just above the lateral aspect of the knee. The entire thigh and leg were the seat of extensive burn scars resulting from injury at eight years of age at which time healing was said to have required many months and skin grafts were not employed. There were several large, firm nodes palpable in the subinguinal region. The patient had first been seen in the outpatient department two years earlier presenting a very large ulceration on the lateral aspect of the thigh which was stated to have been present for only a few weeks. The area of ulceration was widely excised and the defect replaced with split-thickness skin grafts. The microscopic sections were reported as benign although in retrospect some criteria of malignancy were present. The ulcer recurred at the margin of the grafts and was again excised in a similar manner and reported as benign although showing changes suggestive of malignancy. Recurrence again was seen near the knee joint and resection this time showed unquestionable squamous cell carcinoma, moderately well differentiated. Following our observation the area was again excised and the sections showed invasion of the knee joint. Subtrochanteric amputation was then done. The regional lymph nodes showed no microscopic evidence of invasion. The patient remained free from evidence of recurrence or metastasis six months after amputation. (Fig. 4.)

CASE VII. F. S., a seventy year old, colored female, was admitted to the hospital for terminal care presenting a very large, fungating, necrotic lesion of the lower leg. (Fig. 7.) According to the history the ulcer had first appeared three months earlier in an area of atrophic, tight, mottled skin

over the tibial surface. It was assumed that the skin changes were due to vascular disease. The patient was emaciated and practically stuporous. There were numerous large, firm nodes in the inguinal and iliac regions and masses of nodes were palpable in the pelvis per rectum. Mid-thigh amputation was performed on the second hospital day and the patient died eight days later. No autopsy was permitted. Microscopic sections showed the lesion to be a moderately well differentiated squamous cell carcinoma which did not involve the tibia.

#### COMMENT

Five of the seven Marjolin's ulcers presented occurred in burn scars of twenty to fifty years' duration. All were squamous cell carcinomas. Lymph nodes were involved in the cases which were fatal. Cases I and VI illustrate the importance of thorough and frequent biopsies in doubtful cases. In retrospect, it seems likely that the ulcer in Case VI was malignant from the outset and probably already had invaded the fascia planes. It is suggested that in the case of suspicious-looking ulcers in scars of long duration such cellular changes as atypical epidermal proliferation, pearl formation and mitotic figures, even in the absence of clear-cut evidence of invasion, should be considered sufficient to warrant radical surgical treatment. Chances are that if the tissue block is sectioned methodically, some area of frank carcinoma will be found. Our experience as well as that of other observers would indicate that this type of carcinoma remains local for a long time and that radical surgical resection and skin replacement offers an excellent opportunity for cure or long survival if extensive regional or remote metastases have not already appeared. When local bone invasion has already occurred, amputation is the only practical method of treatment. From what evidence is available it seems likely that radical regional lymph node dissections are not necessary unless there is objective evidence of node invasion by carcinoma. In none of our cases of Marjolin's ulcer and in none of the reported cases we have reviewed had skin grafts been employed at the time of original injury. In no instance with which we are familiar has a Marjolin's ulcer occurred in any traumatic lesion which has been adequately skin grafted. It is apparently possible to prevent the occurrence of these ulcers by proper skin replacement even many years after the injury.

November, 1949



FIG. 4. A Marjolin's ulcer of only a few months' duration in scars resulting from frequent ulcerations of the lower extremity presumably due to chronic vascular disease. Case VI.

#### PREVENTION

Every cutaneous scar which is subjected to continuous trauma is a potential Marjolin's ulcer. In addition to constituting a threat to the patient's life, these scars are disabling and disfiguring. All of them can be prevented by the early skin grafting of granulating wounds and by replacement of contracted scars by one of the following means: (1) free grafts, (2) pedicle grafts or (3) Z-plasties.

Scars about the knee joint seem particularly prone to develop ulceration due to the tension of frequent movement but other common regions for Marjolin's ulcers are the face, neck, axilla, groin and foot. Free grafts and Z-plasties will relieve most of the scars that are dangerous but in some regions where maximum elasticity is demanded pedicle flaps are required. For replacement of scars about the anterior surface of the knee, leg and thigh, free grafts are usually adequate. (Fig. 1.) For popliteal contractures where skin loss has been extensive, pedicle flaps are frequently necessary. As a general rule free grafts are used by preference because of their simplicity and minimal time of

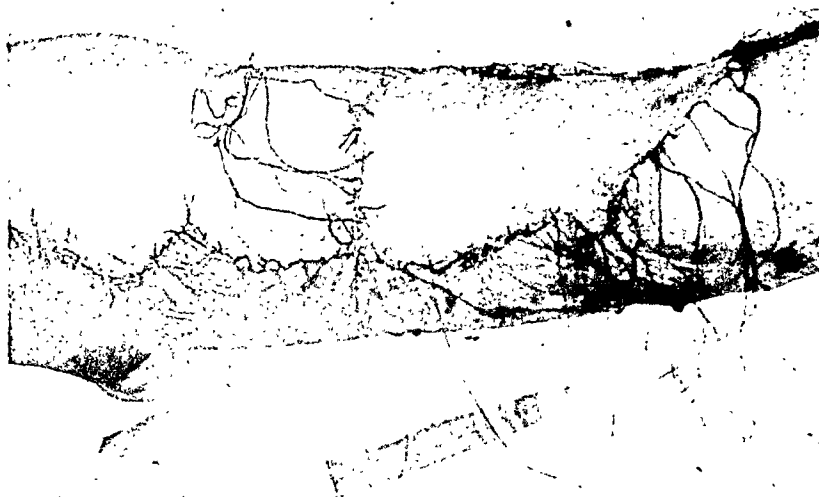


FIG. 5. Illustrates the combined application of a Z-plasty and a free graft in the correction of a contracted scar of the axilla and arm.



FIG. 6. A case illustrating the use of bilateral Z-plasties to relieve relatively narrow contracted bands of the axillae; A, before operation; B, after operation.

disability. In case of doubt a free graft is used and, if necessary, later replaced with a pedicle graft.

Axillary scars lend themselves particularly well to Z-plasties but again, where skin loss is great, the Z-plasty must be augmented by actual skin replacement. (Figs. 5 and 6.) Neck scars also occasionally lend themselves well to correction by sliding flaps or Z-plasties but only when the contracted scar is narrow and surrounded by elastic, normal skin. From a cosmetic standpoint there is no entirely satisfactory substitute for normal neck skin. Free grafts are, however, usually more satisfactory than pedicle grafts. (Figs. 7 and 8.) The preservation of the normal contour is all important in the neck and this can seldom be accomplished by means of pedicle grafts.

Free grafts are ordinarily quite adequate for

extensive scars of the flank and groin (Figs. 9 and 10) but pedicle grafts are occasionally necessary. For weight-bearing surfaces of the foot, thick pedicle grafts are required and even these are far from perfect substitutes for the specialized plantar skin which has no counterpart elsewhere in the body. Plantar skin flaps require proper shoe fitting, special pads and rigorous foot care indefinitely.

We have not had conspicuous success with large, full-thickness, free grafts. The takes tend to be spotty and the end result is often not as good as that obtained with a thick split graft. When the latter is sutured into the defect carefully under somewhat less than normal skin tension, the resulting skin is usually of almost normal thickness and mobility after one or more years. The use of sponge rubber, as described by one of us previously,<sup>16</sup> renders the

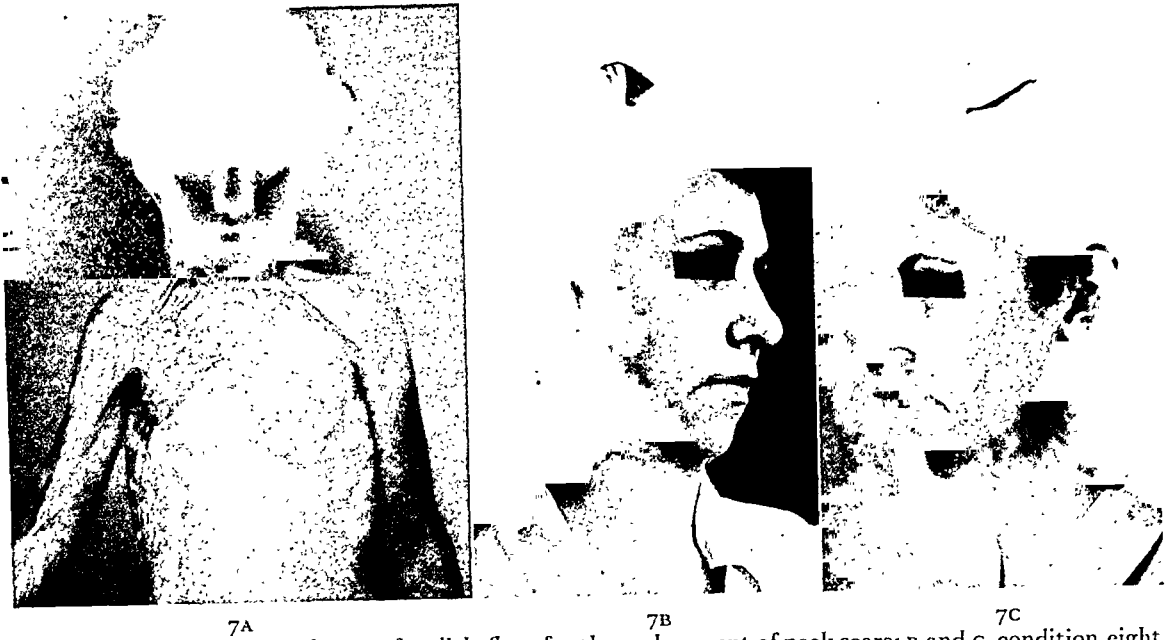


FIG. 7. A, a case illustrating the use of pedicle flaps for the replacement of neck scars; B and C, condition eight years after (A).

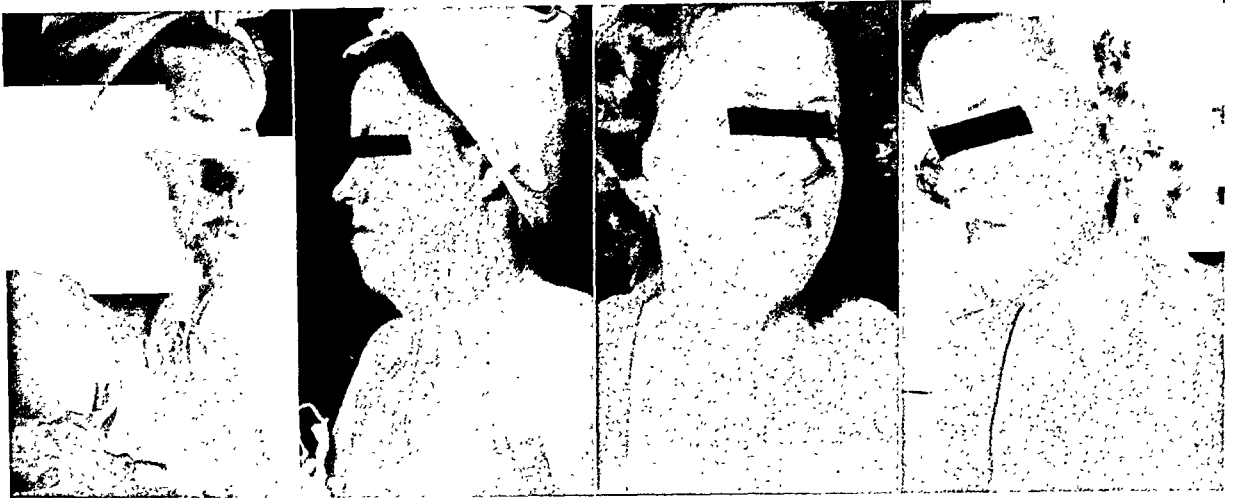


FIG. 8. A case illustrating the use of free grafts for the replacement of contracted neck scars; the postoperative photographs were taken eighteen months after operation.

application and fixation of these grafts relatively fool proof. (Fig. 12C.)

Roentgen irradiation of contracted scars which tend to break down is futile and dangerous as illustrated by the following case:

#### CASE REPORT

J. H., in 1923, at the age of thirty-nine, was severely burned about the face, neck, body and both upper extremities. The burns required almost a year for healing since no grafts were employed. From 1930 to 1935 he was given many x-ray treatments on "keloids" of both forearms. In 1940 he presented extensive malignant ulcers in the irradi-

ated scars of both forearms which biopsies showed to be the seat of well differentiated squamous cell carcinoma. (Fig. 11.) Tendons and nerves of the left forearm were so extensively invaded that amputation just below the elbow was performed. The involvement of the right forearm was consistent with resection and replacement with a large abdominal flap. Bilateral axillary dissections were performed. The nodes showed no evidence of neoplastic invasion. When examined in 1949, the patient showed no evidence of recurrence but tight areas on his neck were beginning to break down.

This patient was continuously disabled for over a quarter of a century as a result of a condition which could have been prevented by the early use of skin grafts.



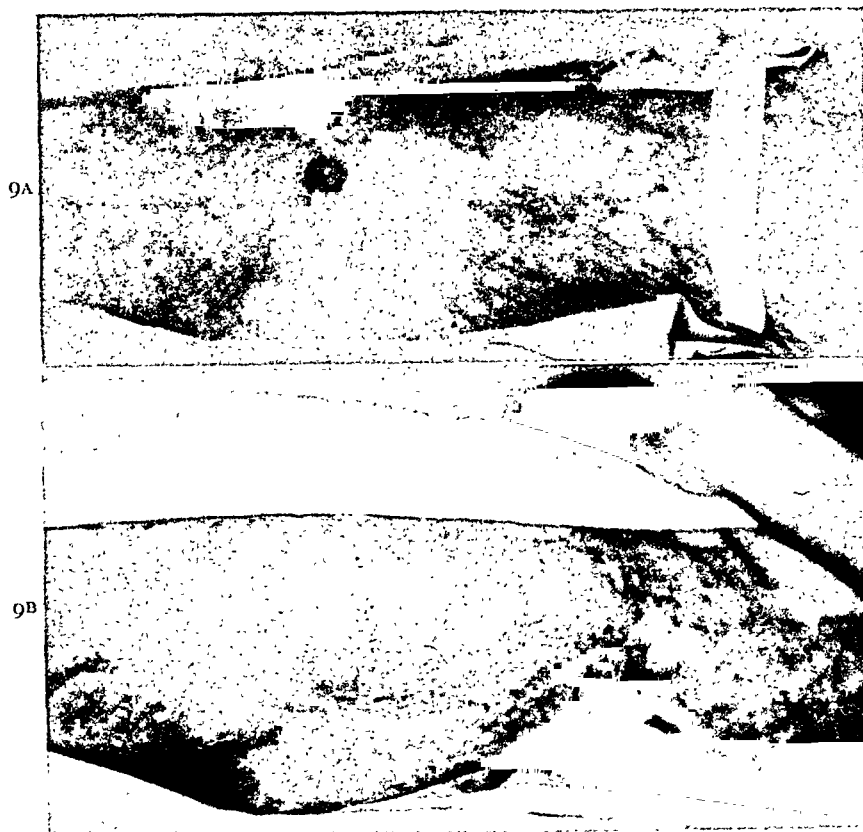


FIG. 9. A case illustrating the use of large dermatome grafts for replacement of a large, tight cicatrix of the chest wall, flank, groin and thigh; A, shows an ulcer in the center of the area of scar which had been present for several years but was not malignant; B, shows the appearance of the graft six months after operation.



10A

FIG. 10. A case similar to that shown in Figure 9 but without ulceration; both were burn scars of more than twenty years' duration. A, shows the appearance before operation; B, shows the scar excised and replaced with three dermatome drums of skin; the difference in size between the excised scar on the wooden block and the skin grafts required to replace it after complete relaxation was obtained is apparent; this photograph also illustrates the use of angles at irregular points in the scar in order to avoid straight lines at the margins of the grafts; C, sutures are left long and tied through and over sponge rubber cut to fit the defect. This method of application practically assures perfect contact of the graft with its bed.



10B

10C

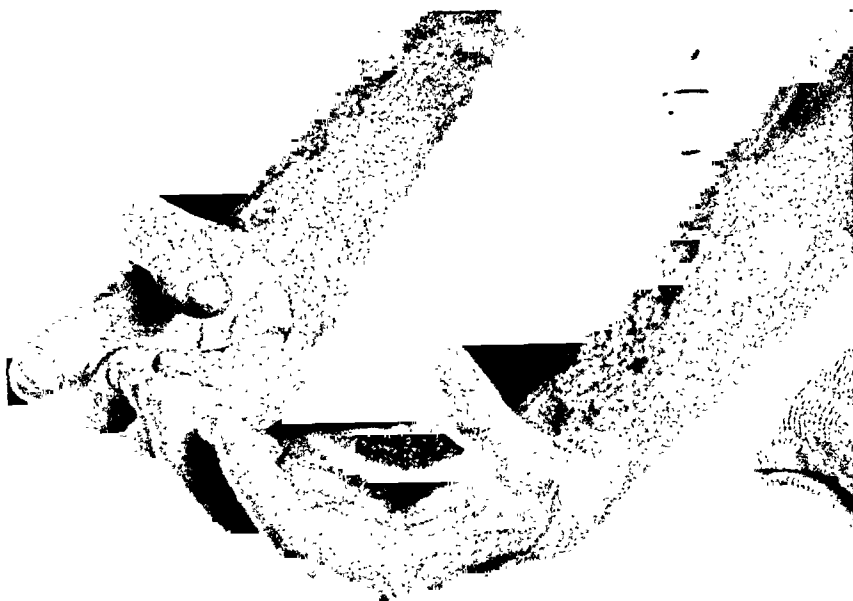


FIG. 11. Bilateral carcinoma in irradiated burn scars of the forearms which required amputation on the left and replacement with a large pedicle flap on the right.

#### SUMMARY

1. Marjolin's ulcer, or carcinoma in a scar, occurs when the scar is subjected to continuous tension or other trauma for a period of years.
2. It is curable by radical surgery before the regional nodes are extensively involved.
3. Marjolin's ulcer is *always* preventable by appropriate transplantation of skin for closure of open wounds and by replacement of dense scars before they break down.

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#### DISCUSSION

GROVER C. PENBERTHY (Detroit, Mich.): Dr. Glover's and Dr. Kiehn's paper is very timely. It brings to our attention and emphasizes again the importance of the follow-up of all burn lesions, especially those that have been skin-grafted. It is timely because today, with the interest in and fear of cancer on the part of laymen and ourselves, this subject brings to our attention a problem that we must handle from year to year.

Dr. Glover has referred to cases of twenty-five years' duration. It is interesting to follow some of the children that we have had in Detroit and see them as adults coming back with a scar and ulcer. It is wise and intelligent to inform all parents that where their children have been burned and skin-grafted, the lesion may require subsequent attention in later years and to watch for this Marjolin's ulcer that Dr. Glover has called to our attention.

I think this paper to begin with is a timely presentation and leads us all to think that these burn

cases, whether they have been grafted or have been allowed to go without grafting, should be watched and followed-up over the years.

HAMILTON A. BAXTER (Montreal, Quebec): I would like to express my appreciation also for Dr. Glover's excellent presentation.

We have tried to follow the general principles which he has outlined in the cases we have seen. However, in our community certain attitudes exist among some, and I believe that they are widely disseminated, which we should strive to correct by constant repetition of certain principles to the general practitioners in our vicinity. So often we see these neglected cases too late. The attitude of prevention is the one that we should try to teach constantly to the general practitioners, each in our own area.

HARVEY S. ALLEN (Chicago, Ill.): It has been our good fortune, or ill fortune, to see many such cases as Dr. Glover has illustrated, and we, too, heartily endorse the program which he has outlined.

We have seen Marjolin's ulcer particularly in burns, which are the most commonly found source. The oldest that we have seen was in a burn of thirty-five years' duration. It had been opened constantly from the time of its inception, thirty-five years of chronic draining wound. The youngest that we have seen was one of eight years' duration.

We have also seen it following osteomyelitis with bone involvement, squamous cell involvement into the bone, in which case, there was wide excision of the bone and the scar and a delayed closure. This had been present for twenty-two years.

One point that I would like to stress and bring again to your attention, however, is that of the x-ray burn, the irradiated areas. Far too often these are neglected and the patient told that he will be perfectly all right when we know that on an average in fourteen years these, too, break down and become malignant.

TRUMAN G. BLOCKER, JR. (Galveston, Tex.): I would like to discuss two recent cases which we have had of ulceration occurring in old burn scar. The first lesion was of thirty-two years' duration and the fungating portion of the ulcer had been present for eight years. Microscopic section showed a sarcoma. At operation the defect was so large after complete excision of scar tissue that five drums of skin were required for complete coverage.

In another instance the patient had had a burn

scar for thirty years which refused to heal. This was of the typical Marjolin type with squamous cell carcinoma. After wide excision in an effort to secure complete relaxation before closure we excised a number of little triangles from the scar edges before applying four drums of skin to cover the area. Dr. Glover mentioned this principle, employing angles or darts in the scarred borders of the wound, in order to relieve the contracture completely and prevent recurrence of scar bands in line of function.

JOHN E. CANNADAY (Charleston, W. Va.): The majority of ulcers of this type that I have seen and dealt with have been below the knee. They usually are very susceptible to traumatism, even to slight trauma. I have found that lumbar gangliectomy, which can be done extraperitoneally, facilitates healing very much, particularly when you come to applying skin grafts.

I have observed also that postural treatment can be of decided value in these conditions as, for example, getting the patient to keep the part of the limb involved elevated at a higher level than the body most of the time. This type of treatment if faithfully carried out materially helps to prevent recurrence.

DONALD M. GLOVER (closing): I wish to thank the discussers for their kind remarks and comments.

The time element, which has been mentioned by several of the discussers, is perhaps the key factor in the development of these ulcers. We do not know how long it takes for a malignant ulcer to develop. In one of our cases it occurred after fifty years. Another point is the similarity between Marjolin's ulcers and those which occur in irradiated areas. While irradiation carcinoma is not, strictly speaking, a Marjolin's ulcer from the standpoint of the original description, the mechanism is almost identical and there is no reason for considering them in any different light. The ulcers are open to suspicion as long as they exist and the only possible method of preventing malignant change is to get rid of the damaged tissue and get rid of it early.

In regard to the postural management brought out by Dr. Cannaday, I agree that in some cases it is helpful in preventing contractures. It is my conviction, however, that it is impossible to overcome loss or deficiency of skin by any other means than by actual replacement.



# PERTINENT FACTORS INFLUENCING REPAIR IN TRAUMATIC WOUNDS\*

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IN the book, "Marrow of Chirurgery," which was written in 1685, James Cook of Warick, "Practitioner in Physic and Chirurgery," defines a wound as follows: "A wound is a solution of unity in any part of the body by an external instrument. They receive their differences from their magnitude, part wounded and their cause."<sup>1</sup> It would be difficult to find a more concise and descriptive definition.

Excluding wounds deliberately made during surgical procedures, all wounds are soiled and potentially infected due to organisms carried in by the "external instrument" at the time of wounding. Fundamentally wounds caused by instruments of war are no different from those encountered in civilian life. It is a question of magnitude. Because of the jagged contour of shell fragments, war wounds are generally far more destructive than civilian wounds. Furthermore, much more foreign material such as dirt and soiled clothing is carried into the depth of the wound. With this foreign material a variety of most virulent pathogenic organisms may be introduced. The terrain and the patient's environment at the time of wounding may influence the type of organisms introduced and should be considered. In this connection one might reflect upon the increase in the incidence of virulent gas infection in Italy during World War II as compared with its almost non-existence during the African Campaign. Also, in war wounds the delay between injury and treatment is of necessity longer than usually encountered in civilian wounds, all of which adds up to a wound (Fig. 1) with marked tissue destruction which is soiled and in which the potentialities of infection are far greater.

In the early part of World War II every medical officer was treating patients according to his own individual plan and policy.<sup>2</sup> Some of the methods employed were very good while others were very poor. It was at this time that a follow-up study and evaluation of 498 battle

casualties was accomplished. (Table 1.) This necessitated the visiting of twenty-eight American, British and French hospitals throughout



FIG. 1. Appearance of a war wound of the thigh showing marked tissue destruction and soiling. A severe invasive infection (clostridial myositis) has developed.

North Africa in addition to the Surgeons' offices in Algiers, Oran and Casablanca. Thus an excellent opportunity was provided to evaluate some of the fundamental principles and pertinent factors influencing the repair of over 1,000 traumatic wounds.

This follow-up study in addition to observations on a large number of other patients treated by other surgeons revealed numerous professional sins of omission and commission some of which were still in evidence in the European theater as late as February, 1945. Briefly, these were: (1) an improper concept of débridement; (2) saucerization or sacrifice of too much skin; (3) plugging of the débrided wound with sulfanilamide powder, vaseline gauze or both; (4) primary suture of débrided wounds; (5) tampering and fussing with the wound either before or following débridement; (6) insufficient immobilization of the débrided wound and (7) an almost total ignorance of the procedure known as delayed suture. With the exception of the overuse of sulfanilamide it is

\* From the Department of Research Surgery of The Ohio State University, Columbus, O. Aided by a Grant from the Comly Fund for Research of The Ohio State University.

interesting to note that our attention was directed to these same errors following World War I.<sup>3</sup>

DÉBRIDEMENT

Undoubtedly the greatest hazard to healing encountered in traumatic wounds is infection

civilian wound. On the other hand, the extent of the application of that principle may differ in the two types of wounds. It is our impression that the débridement of a wound is an operation of incision and excision. (Fig. 2.) The skin is incised in the long axis of the limb. Unnecessary sacrifice of tissue, especially the skin,

TABLE I  
PERTINENT FACTORS INFLUENCING REPAIR IN TRAUMATIC WOUNDS\*

	Per Cent of Total	Inter- viewed	Duty	Limited Duty	Z.I. (U.S. or U.K.)	Deaths	Per Cent Fatal- ity	Total
Debridements..... (Soft tissue)	47.7	58	134	11	29	0	0	232
Compound fractures.....	24	22	10	4	72	2	1.8	110
Simple fractures.....	2	..	3	..	7	0	0	10
Thoracic (penetrating or perforating)								
a. Sucking.....	...	3	4	..	7	3	9	33
b. Non-sucking.....	6.6	1	8	1	6	0		
Amputations.....	6.4	2	2	..	25	3	9	32
a. Shoulder 2 { 1 also had sucking chest								
b. Arm 4 { injury								
c. Forearm 3 {								
d. Thigh 4 { 1 also had head injury								
e. Leg 20 { and 2 had abdominal								
f. Foot, fingers, toes 3 { injury								
Abdominal.....	5	4	2	2	12	5	25	25
a. Colon only 4.....	...	..	...	..	..	1		
b. Small bowel only 3.....	...	..	...	..	..	0		
c. Colon and small bowel 6.....	...	..	...	..	..	3		
d. Colon and stomach 2.....	...	..	...	..	..	0		
e. Colon, stomach and liver 1.....	...	..	...	..	..	0		
f. Liver 1.....	...	..	...	..	..	0		
g. Liver and kidney 1.....	...	..	...	..	..	0		
h. Spleen 1.....	...	..	...	..	..	1		
i. Abdominal injury without visceral perforation 6.....	...	..	...	..	..	0		
Thoraco-abdominal..... (Sucking chest, diaphragm, spleen, liver, stomach, colon, small bowel)	.8	..	...	..	2	2	50	4
Abdomens not operated..... (Moribund)	.4	..	...	..	..	2	100	2
Head.....	4.4	1	4	3	7	7	33.1	22
Head and chest.....	.2	..	...	..	..	1	100	1
Maxillo-facial.....	3	2	6	1	6	0	0	15
Burns.....	1.2	3	3	..	..	0	0	6
Gas infections.....	.8	1	...	..	3	0	0	4
Spinal cord.....	.4	..	...	..	1	1	50	2
Totals.....	...	..	...	..	..	26	....	498

and certainly a most important factor in eliminating infection is a thorough débridement. It has been our belief that the principle of débridement is the same regardless of whether we are dealing with a military or

should be avoided as it is particularly resistant to infection. The wound is then incised or enlarged until its full extent is visualized. The enlarging is carried out in the direction of fascial planes and muscle fibers. All foreign

material, traumatized and devitalized tissue including muscle and unattached bone fragments, are meticulously removed or excised. (Fig. 3.) If the wound is properly débrided, this principle must be followed relentlessly and may in certain instances even necessitate the

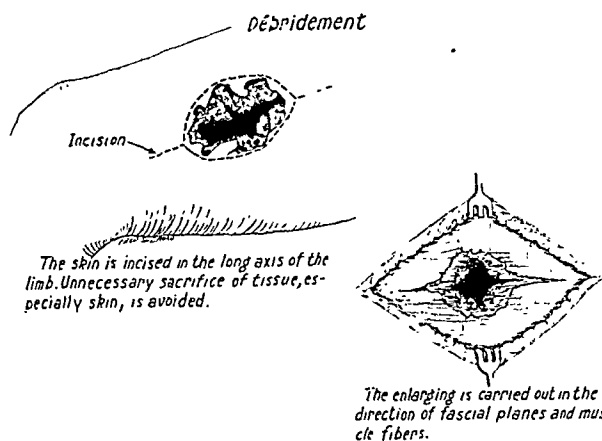


FIG. 2.

removal of an entire muscle or muscle group. (Fig. 4.) Direct vision of the extent of the wound not only assures us that major nerves and blood vessels will be preserved but also that hemostasis will be rigidly secured. (Fig. 5.)

Lest it be thought that these ideas are new, the following statement is quoted from "The Marrow of Chirurgery" published in 1685: "Cure is performed, first, by removing extraneous bodies which are so either by accident, as contused flesh, clotted blood, bones, gristles, pieces of membrane, tendons or hairs, or of their own nature, as pieces of garments, weapons, steel, lead, shivers of wood, gravel, etc. These are to be removed, such as may be by washing, others by forceps."<sup>1</sup>

Experience has certainly proven the efficacy of gentle but thorough cleansing with soap and water followed by copious irrigations with sterile saline or water.

In Table 1 it is noted that there were 232 casualties whose wounds were limited to the soft tissues and who, therefore, were classified as débridements. Most of these were major in extent involving deep muscle and fascia. Of the twenty-nine patients who had been evacuated to the Zone of the Interior, nineteen had wounds which were quite extensive, involving the upper thigh and buttocks. Two had complicating eye injuries, two severe nerve injuries and three had developed a psychoneurosis. The remaining three patients had very severe infections in their wounds.

November, 1949

Of 228 patients with uncomplicated soft tissue wounds, 134 were returned to full duty and eleven to limited duty. Of those returned to full duty, the longest period of hospitalization was 125 days and the over-all average was 39.3 days. Of those returned to limited duty, the

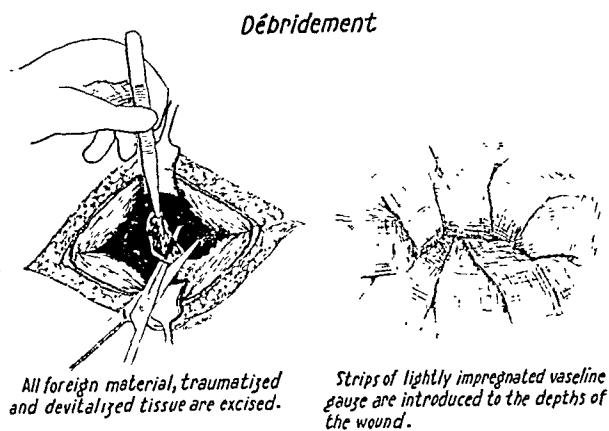


FIG. 3.

average period of hospitalization was 52.8 days, the longest period being 127 days. There were 266 casualties who had other major injuries (thoracic wounds, abdominal wounds, etc.) in addition to their soft tissue wounds. It should be emphasized that virtually all of these had



FIG. 4. Muscle excised in the débridement of a wound; clostridial myositis was present.

one or more wounds which required débridement. (One casualty had thirty such wounds).

This study revealed that with the exception of wounds of the hand, face or scalp, primary suture *should never be utilized* in war wounds. Even when aseptic excision *en bloc* procedures were accomplished, 50 per cent of those primarily closed became infected. Following débridement it was learned that the wound may be lightly dusted or frosted with sulfanilamide crystals and this in turn covered with lightly impregnated vaseline gauze introduced to the depths of the wound. (Fig. 3.) This amply allows for drainage. The vaseline gauze may

then be covered with fluffed sterile gauze and a pressure dressing applied; lastly, the wound should be well immobilized by means of a plaster splint or encasement. If the latter is used, the importance of splitting or preferably bivalving the cast cannot be overemphasized.

The blind digital exploration of a wound tract while looking to the heavens for divine guidance has no place in débridement.

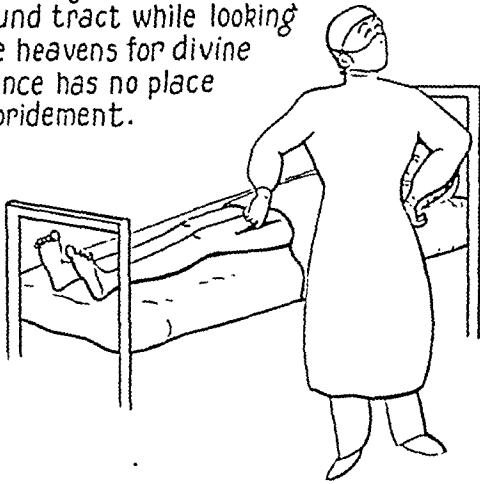


FIG. 5.

#### SECONDARY WOUND INFECTIONS

Another pertinent factor which delayed wound healing in this series of patients was secondary wound infection. It is first essential that the basic difference between primary and secondary wound infections be fully appreciated.<sup>4</sup> Primary wound infections are those caused by bacterial contamination at the time of injury. These bacteria are derived from the soil, clothing, skin and foreign bodies. Secondary wound infections, on the other hand, are those caused by bacteria introduced into the wound at any time after the initial injury.

These secondary infecting invaders may come from the respiratory tract of the patient, the unmasked nurse, surgeon or ward attendant. They may come from the skin of anyone touching the wound or from unsterile instruments and dressing exposed to dust-laden air. Dust kicked up from the floor by a passing attendant or air currents created by movements of the patient or his bedclothes, during inspection and dressing are also possible sources of secondary organisms.

DeWaal<sup>5</sup> in a bacteriologic investigation of 708 wounds found that when first-aid "cleansing" of wounds was done, more than twice as many infections occurred as when the wound was simply dressed without any attempt to

"cleansing" it. Edwards<sup>6</sup> and others<sup>5,7</sup> noted a decided increase in infection in those wounds which were redressed *en transit* from forward to base hospitals over those which had not been disturbed. At the time of this follow-up study it would almost have been considered negli-

#### INSPECTION MEANS INFECTION

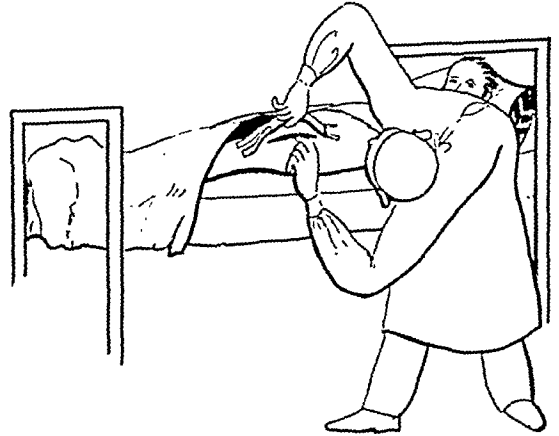


FIG. 6. The impulse to change a dressing or to peep at a wound is difficult to resist. However, the statement, "inspection means infection," is so important that it should be impressed upon the mind of every surgeon charged with the care of open traumatic wounds.

gence, if the ward surgeons did not inspect, redress and otherwise tamper with the patients' wounds. When these patients were interviewed and their wounds inspected at base hospitals, none were found who thought that their injuries had been neglected. At each hospital to which they had been admitted for a few hours or days in their long evacuation en route from Tunisia, their soiled dressings had been replaced by fresh ones and quite frequently their dirty and somewhat uncomfortable casts had been replaced by new ones. This is not offered as a criticism. It was the generally accepted policy.

Caldwell<sup>4</sup> has stressed an appalling incidence of secondary infections in hospitalized patients with open wounds stating that it is actually the principal cause of delayed healing and impaired function. It was his opinion that at least half of the serious, persistent infections in wounds were caused by bacteria secondarily introduced. He found only 5 per cent of fresh wounds infected on admission to the hospital but after a week in the institution 50 per cent of the wounds contained secondary invaders;

later they were found in 70 to 80 per cent of open wounds.

The impulse to change a soiled dressing for a clean one or just to peep at the wound is only natural and most difficult to resist. However, the statement "Inspection Means Infection" is one of such importance that in some manner it should be permanently impressed in the mind of every surgeon charged with the care of open traumatic wounds. (Fig. 6.)

#### DELAYED SUTURE

The evolution of the concept of delayed suture was slow and fraught with confusion and little was carried forward from experiences during the last war.<sup>9-11</sup> Several different formalities, technics or methods of closure were utilized, each having its ardent advocates. One of these, consisting of preliminary inspection, bacteriologic cultures of wound flora and preliminary wet dressings, was used in World War I and has been described in detail by Pool.<sup>9</sup> Although this routine was used to some extent in World War II, *a noteworthy contribution to wound management has been the revelation that this procedure or any part of it is not only unnecessary but actually detrimental to best results.*

In this series of 498 patients in whom a follow-up study was conducted there was, to our knowledge, not one single instance in which the patient's wound or wounds had been given the advantage of delayed suture. This program had not as yet been initiated so all wounds were allowed to heal by granulation. Many of those patients whose wounds had healed at the time of our interview had developed deep, deforming, contracted scars which required extensive physiotherapy and rehabilitative measures. (Fig. 7.)\* Capper<sup>8</sup> in a small series of unselected thigh wounds found that the average time away from duty was 104 days for unsutured wounds and eighty-eight days for those which had been sutured. Furthermore, 90 per cent of those patients whose wounds were sutured returned to full duty compared with 54 per cent of those whose wounds were not sutured.

While several factors appear to influence the



FIG. 7. Deep, deforming, contracted scar present in a wound which healed by granulation.

relative success of delayed suture, Lowry and Curtis reported a subsequent analysis of 721 wounds sustained by 360 consecutive, unselected patients which revealed that the most important single factor was the time interval between the initial surgery and the delayed suture.<sup>12</sup> This analysis revealed that the optimum time interval in which to close a wound was four to five days following the initial surgery. At this time the tissues were found to be soft and pliable; moreover, they could be approximated without resorting to wound trimming, excision or undermining. Beyond the optimum time interval this analysis revealed that the wound edges soon became fixed with an inversion of the epidermis. Trimming and excision with extensive undermining were often necessary to effect approximation without tension. The prolonged time interval with the added trauma required to accomplish a delayed suture resulted in a pronounced drop in percentage degree of healing. Moreover, they found that when wounds were closed prior to the fourth and fifth day (97 per cent healing) optimum time interval, only 86 per cent healing occurred.

This observation is quite striking in the light of the experimental work of Berman and his associates.<sup>13</sup> They found that a localized immunity against infection was not present in wounds up to twenty-four hours old but began on the second day, increasing to attain 100 per cent on but not before the fourth day.

It is admitted that many traumatic wounds occurring in civilian practice may be safely

\* Figures 1, 4, and 7 were made by photographic units of the Museum and Medical Arts Service of the U. S. Army Medical Museum. Figures 2, 3, 5 and 6 were prepared by the Department of Photography from illustrations drawn by William F. Shepard, Medical Illustrator of The Ohio State University.



closed immediately following their débridement. If, on the other hand, healing approaching 100 per cent can be obtained by utilizing delayed suture,<sup>12</sup> it would appear that those wounds associated with marked tissue destruction and severe contamination or a prolonged time lag between injury and treatment should best be left open for delayed suture. Furthermore, it appears not only possible but desirable in some instances to extend the application of delayed suture well beyond the realm of traumatic surgery; for example, McLachlin<sup>14</sup> has demonstrated quite conclusively the advantage of delayed suture in diabetic gangrene. Several surgeons, including ourselves, have utilized delayed suture in the abdominal wound of patients suffering from ruptured appendicitis with localized or generalized peritonitis. It has also been used with advantage in the treatment of patients with pilonidal sinuses. It therefore appears that in any wound in which there is risk of infection it may be more safely handled by waiting until localized immunity has fully developed before attempting a closure.

World War I experience dictated that preliminary bacteriologic cultures should be accomplished on all wounds before a closure is attempted. It is admitted that these rather time-consuming studies are of investigative interest and they have contributed much to the fundamental knowledge of wound management. However, except in the presence of an established gross infection, routine bacterial cultures of the wound flora are of no practical value. Even in the absence of gross infection, streptococcus, staphylococcus, proteus, pyocyanus and even clostridial organisms are frequently found and have been shown to persist in these traumatic wounds<sup>5</sup> yet seldom interfere with healing.<sup>15, 16</sup>

#### WET DRESSINGS

Since the dawn of modern surgery the search for the ideal antiseptic has been constant and universal. It is well known that the ability of most antiseptic agents to sterilize a wound is at best questionable. Many which are highly efficient in a test tube show less efficiency in a wound. Moreover, most antiseptic agents which are bacteriocidal exert an equally damaging influence on the tissue thus creating an excellent culture medium for surviving organisms.

During World War II the evolution to our present concept of delayed suture included a

period during which open wounds, although appearing grossly clean, were subjected to various types of wet dressings. These were changed daily for forty-eight to ninety-six hours prior to delayed suture. In some quarters it appears that this practice persisted until the end of the war. Our experience with this formality is limited to eighty-three clinically clean wounds only eight of which are included in the series of 721 wounds previously mentioned. Each wound was evaluated on a degree of percentage basis and no wound was considered 100 per cent healed unless primary repair had occurred throughout at the time the sutures were removed. Only 79 per cent healing was obtained in those wounds in which preliminary wet dressings were used as compared to 91 per cent in all wounds in which they had not been used. While this experience is small, it was sufficiently discouraging so the practice was entirely abandoned unless there was obvious evidence of infection when the patient was first examined or when his initial dressings were removed in the operating room.

Therefore, it appears that the application of any wet dressings to an open wound introduces the hazard of secondary invaders, prolongs the important time interval between initial surgery and delayed suture and certainly, as in this study, results in a reduced percentage of healing.

#### INFECTIONS

If wet dressings are utilized at all, they should be reserved for those wounds in which gross infection is present. As previously reported<sup>12</sup> infections were present in 15 per cent of the preoperative and 21 per cent of 721 postoperative wounds.

At the present time some investigative work with Bacitracin\* is in progress in pre- and postoperative wound infections. In the more severe, localized infections bacitracin solution, 500 units per cc. in combination with 1 per cent novocain, is infiltrated around the site of the infection in quantities of 5 to 10 cc. Twenty cc. have been used with no deleterious effect. The range of antibiotic activity of bacitracin is in general similar to that of penicillin. On the other hand, there are some penicillin-resistant

\* This antibiotic agent was first reported by Meleney and co-workers in *Science*, 102: 376, 1945. It has been supplied through the generosity of C. S. C. Pharmaceuticals, a division of the Commercial Solvents Corporation, New York 17, N. Y.

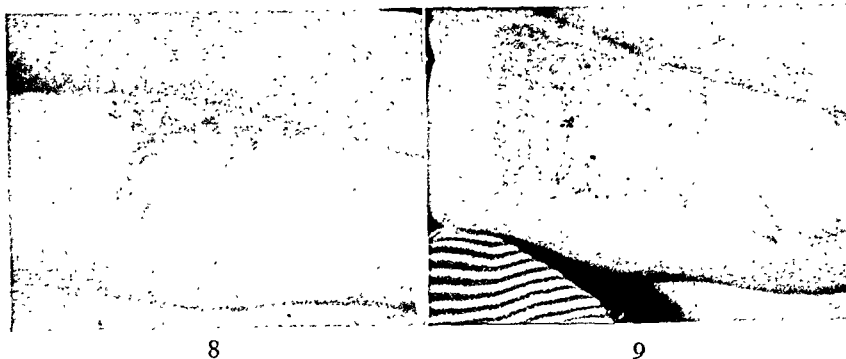


FIG. 8. Traumatic wound of leg with considerable loss of skin after primary suture. Secondary debridement, secondary suture, and skin graft; loss of portion of skin graft; epithelization promoted with chloresium solution and ointment. FIG. 9. Same case as Figure 8. Skin graft cut too deeply; epithelization promoted with chloresium solution and ointment.

organisms which are bacitracin sensitive. The solution is prepared by mixing with 2 per cent novocain a previously prepared stock solution made up with sterile saline in a concentration of 1,000 units per cc. Just prior to infiltration one-half of the desired quantity of bacitracin is mixed in the syringe with an equal quantity of 2 per cent novocain. Very little discomfort has been experienced. The infiltration is supplemented with topical applications of the solution. Fine mesh gauze is introduced into the depth of the wound which is covered with a piece of sterile rubber sheeting. At intervals of three to six hours the rubber sheeting is lifted and the gauze resaturated with 1 to 5 cc. of the solution as required.

In wounds with less severe infections topical applications of the solution or ointment have been utilized. The solution has appeared to be slightly more efficacious so in hospitalized patients it is generally used in preference to the ointment. Furthermore, infiltrations appear to possess distinct advantages over topical applications alone.

The number of wounds thus treated is too small for us to arrive at any definite conclusions but the results have been much superior to those in which one of the usual wet dressing solutions had been used. At the end of twenty-four to seventy-two hours the wound usually appears clinically clean and ready for delayed or secondary suture or skin graft. (In a wound previously sutured the term secondary suture applies.) It should be emphasized, however, that the same error should not be committed as occurred with the sulfa drugs. Bacitracin has not replaced any of the fundamental principles of good surgery. Adequate drainage with the

removal of all necrotic and devitalized tissue still remains the keynote in the management of infected wounds.

Some clinical investigation is also in progress with chloresium.\* In certain instances when partial loss of a skin graft has occurred (Fig. 8)

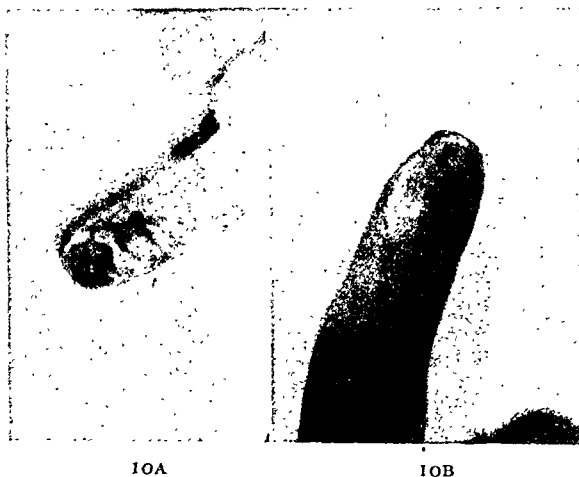


FIG. 10. A, loss of skin in traumatic wound of index finger; B, entirely healed fourteen days later.

or when the skin graft has been cut too deeply resulting in a delay in epithelization of the donor site (Fig. 9), chloresium has been utilized advantageously. Other instances of traumatic wounds of the digits and elsewhere in which a loss of epithelium has occurred have been encountered. (Fig. 10.) When this loss has not been too extensive, daily applications of chloresium ointment have been utilized rather than hospitalizing the patient and doing a skin graft.

\* Chloresium is the trade name for the water soluble chlorophyll derivative preparation used in this study. It has been supplied through the generosity of the Rystan Company, Inc., Mt. Vernon, N. Y.

Again the series of wounds in which this preparation has been applied is too small for final evaluation. Nevertheless, the results thus far obtained have been impressive. This limited experience indicates that the lag phase of repair is shortened and that epithelization is definitely accelerated.

#### PRESSURE DRESSINGS

In the two series of wounds under consideration the dressing was quite important and, if properly applied, was a definite aid to healing. A certain amount of edema is invariably present in traumatic wounds following débridement and at the time of closure. Any undermining of the skin edges or revision of the wound is almost certain to be attended with increased loss of local fluid or exudation. This increase in local edema naturally leads to an increased tension of the suture line. Tissue approximated under tension is notorious for its failure to heal. Furthermore, tissue which is boggy with edema will not heal. Therefore, it can be readily appreciated that every effort must be made to minimize and decrease local edema following a delayed suture or skin graft. A pressure dressing with mechanics waste and an elastic bandage was found ideal as it not only retarded the loss of local fluids but also tended to reduce the edema already present.

The favorable influence of selective, purposeful mechanical pressure on wound healing was discussed by Blair<sup>17</sup> in 1924. He listed four basic ends to be gained: (1) elimination of dead spaces; (2) control of oozing; (3) limitation of stasis and (4) limitation of the amount of plastic substance that pours into the wound. Of additional interest was the observation of Twyman<sup>18</sup> that epithelium proliferates readily when subjected to a pressure that restrains the growth of connective tissue. Thus by regulating the bandage pressure to an amount which corresponds to that required to blanch the finger nail, the granulation capillaries are compressed or collapsed and the tissue is repressed while epithelial growth proceeds unaffected.

Elevation of the extremity postoperatively for a minimum of twenty-four to forty-eight hours is, on theoretical grounds, an adjunct in decreasing local wound edema. This aids in draining lymph and venous blood by gravity thereby relieving stasis and improving local circulation.

#### IMMOBILIZATION

It has been previously mentioned that traumatic wounds should be well immobilized especially following débridement. The lack of adequate immobilization was one of the major errors of omission in the early phase of World War II. (Table 1.) The contrast in the comfort of the patient and the appearance of the wound between those patients whose wounds had been properly immobilized and those in whom this pertinent factor had been omitted was most striking.

Following delayed suture immobilization is also a definite adjunct to wound healing. It prevents the disruption of fibroblastic and vascular strands of new tissue by movement or tension. In wounds complicated by fracture, nerve or tendon suture and in wounds involving or in the vicinity of joints, immobilization should be absolute and in a position favoring function and approximation without tension. However, in most uncomplicated, soft part wounds it was not found necessary to practice rigid splinting in plaster encasements or moulded splints. Pressure dressings with the patient's cooperation at bed rest provided the immobilization required for firm and rapid wound healing. After twenty-four to forty-eight hours of elevation the limited movement which a patient at bed rest may give a sutured extremity encased in a pressure dressing is advantageous in that it favors lymphatic drainage which further reduces wound edema. Furthermore, adhesion of sutured skin to underlying tissue was thereby discouraged which, with early ambulation after suture removal, considerably lessened the need for extensive physiotherapy. Modified rather than absolute immobilization of uncomplicated soft tissue wounds was apparently a contributing factor in the earlier return of these patients to duty.

#### BLOOD

The life-saving value of blood replacement in trauma and in all major surgical procedures is now generally accepted. At the time of the follow-up study, illustrated in Table 1, this vital item was conspicuous by its absence in the forward areas (clearing stations) where the initial surgery was accomplished. Some few very major casualties received 500 cc. (rarely more) of blood obtained from the personnel of the clearing station or attached surgical

team. Plasma and glucose were available and certainly contributed to a lower mortality than would otherwise have been experienced. Later, as field hospitals became available, blood banks were organized.

It would be difficult to estimate the immense contributions which available blood replacement made during World War II. Of 375,000 battle casualties in the European theater who lived to reach a medical installation, the mortality was 3.9 per cent as compared to approximately 10 per cent in World War I.<sup>19</sup> While several factors contributed to this remarkable drop in mortality, a major one was probably the improved understanding of shock and its resuscitation with plasma and blood. On many occasions we have observed wounded soldiers brought into the field hospital more dead than alive. They were cold, listless, ashen gray in color and neither a pulse nor blood pressure was obtainable. At times their state of shock was irreversible but frequently under the influence of blood and plasma, which was pumped into three or four veins simultaneously, they have revived, undergone a major operative procedure and lived. (One personal patient who survived received 5,500 cc. of blood before, during and immediately following his surgery.)

The subsequent analysis of 360 patients with 721 traumatic wounds was accomplished in an overseas base hospital approximately two years after the follow-up study recorded in Table I. During this period many notable improvements in the care of wounds had been accomplished.

The majority of patients with soft parts and fracture wounds arrived on the third to the sixth day following their débridement. Although most of them were in excellent condition, a few were quite ill with an established sepsis, a gas infection or a secondary hemorrhage which demanded immediate attention. Therefore, early examination and evaluation became mandatory.

In evaluating these patients considerable importance was attached to their hemoglobin, hematocrit and plasma protein determinations. The rapid copper sulfate method of calculating these values described by Phillips et al.<sup>20</sup> had been introduced and proved most satisfactory. From these determinations their requirements of fluid, plasma and blood could be outlined fairly accurately. Fortunately, good copper sulfate was provided and an excellent chemist to make up the stock solution was available.

Aware of the urgency of early wound closure, every effort was made to prepare these patients for surgery as rapidly as possible. Virtually all of the more severely wounded needed blood in varying amounts of from 500 to 2,000 cc. *It became evident that blood replacement was fully as important as chemotherapy in controlling infection and promoting wound healing.*

#### HYPOPROTEINEMIA

Protein deficiency as determined by reduced plasma protein determinations was present in most of the seriously wounded patients on admission to the hospital. This was surprising in view of the seemingly adequate blood and plasma many had received at forward hospitals. While uncorrected blood loss and initial surgery contributed, a major cause for this deficiency must have been an inadequate diet.<sup>21</sup> It has been previously mentioned that every effort was made to correct their hemoglobin, hematocrit and plasma protein levels before operation but it was frequently astonishing to find low determinations again following surgery.

The retarding influence of hypoproteinemia on wound repair is now well established. Elman,<sup>21</sup> Meyer and Kozoll,<sup>22</sup> Davis<sup>23</sup> and others<sup>24-26</sup> have thoroughly reviewed and stressed the frequency, recognition, prevention and treatment of this challenging issue in recent contributions. Clark<sup>27</sup> found that on a high fat diet wound healing did not begin for six days while on a mixed diet it began in four days. On a high carbohydrate diet the quiescent period was three days while on a high protein diet healing began at once. Thompson, Ravdin and Frank<sup>28</sup> in 1938 found that on a low protein diet abdominal incisions in eight of eleven dogs failed to heal. In 1940 Ravdin<sup>29</sup> stated that cellular repair and regeneration require protein and that in the absence of adequate amounts of essential amino acids growth cannot occur.

Protein metabolism is also concerned with resistance to infection.<sup>25</sup> Elman<sup>21</sup> has pointed out that lowered resistance to infection is demonstrated by the fact that the production of antibodies is but one-third to one-fifth as great in protein-deficient animals as in animals on a regular diet. He concludes that probably many postoperative infections may be due in part to a lowering of the immunologic response of the body secondary to protein starvation. Thus while virtually all of the partial to com-

plete failures in this study were attributed to infection, it is quite probable that at least some of these postoperative infections were due in part to protein deficiency. Elman has further pointed out that although hypoproteinemia occurs frequently after injury or surgery, its existence may often be masked by an associated dehydration or an increase in the globulin fraction due to an infection.

In this connection another factor of importance emphasized by Metcalf and Starr<sup>26</sup> is that the total plasma volume should also be known to interpret a plasma protein determination correctly. Thus 6 Gm. per 100 cc. in a patient with a plasma volume of 2,000 cc. is considerably different (60 Gm.) from the same value in another patient with a plasma volume of 1,000 cc. Therefore, in conditions associated with plasma and blood loss such as acute hemorrhage (intestinal bleeding, lacerated vessels and skeletal trauma) or local plasma loss (burns and peritonitis), the total plasma volume might be quite diminished yet the plasma protein determination might not reveal a marked reduction.

Adequate diet and multivitamin intake was encouraged in our patients in a deliberate effort to maintain their general resistance at a high level. When a reduced plasma protein determination was noted with unaltered hemoglobin and hematocrit values, intravenous plasma was used in an attempt to repair the protein deficiency. While it appeared that this method of treatment was quite effective, it is now recognized<sup>25</sup> that more efficient methods are available. Up to 150 Gm. or more of protein per day may be given intravenously in the form of hydrolysates or amino acids to which may be added glucose for its protein-sparing effect. Oral or, if necessary, tube feedings utilizing one of the skim milk powder formulas have been employed extensively and have been found to be not only economical but also a very satisfactory method of treating protein deficiency.

#### CONCLUSION

The history of the healing of a wound is the history of surgery.<sup>30</sup> At any rate it is a fundamental subject and one which has received increasing attention during the past few years. Arey<sup>31</sup> in 1936 presented a most comprehensive review which reveals many of the factors which may influence wound healing. Therefore it would appear advantageous to reflect for a

moment on the factors which influenced repair in these traumatic wounds and translate, if possible, this military experience into a concrete plan of management which could apply in any traumatic wound.

From the moment of a wound's inception this one objective should be uppermost: prevent infection and preserve life and limb. This may be accomplished by full application of every means at the surgeon's command and begins with the first aid treatment at the scene of injury. This should include the control of pain by hypodermic and the control of hemorrhage by pressure or tourniquet, the application of a firm sterile dressing with *no attempt at preliminary cleansing* and immobilization of the wounded part. Resuscitative measures such as hot drinks and intravenous plasma may be utilized if indicated and available. In transit to the hospital the patient's body heat should be preserved with the judicious use of warm blankets. Reinforcement or readjustment of dressings may be necessary but the error of a change of dressing (except for continued active hemorrhage) is *strictly avoided*. With the patient's arrival in the hospital further resuscitative measures including a correction of reduced blood volume are employed as indicated. The patient is routinely given prophylactic tetanus antitoxin or a stimulating dose of tetanus toxoid. Such fluoroscopic and x-ray examinations as are indicated should be accomplished when the patient's condition permits.

Having determined the extent and circumstances under which the injury was incurred, a thorough débridement of the wound with meticulous removal of all devitalized tissue and foreign bodies is accomplished. To supplement the effectiveness of initial surgery in minimizing or preventing infection, bacterial proliferation is arrested through the intelligent employment of local and systemic chemotherapy (or antibiotic therapy). If the tissue is severely traumatized and the wound grossly contaminated, it is wisely left open with lightly impregnated vaseline gauze strips introduced to its depths thus providing for adequate drainage. Lastly the wound is well immobilized. Following the initial surgery inspections of the wound and redressings are rigidly avoided (unless a secondary hemorrhage or an unexplained sepsis develops) thus excluding the probable introduction of secondary infecting organisms.

At the end of four to five days the patient is again removed to the operating room where his dressings are removed and the wound evaluated upon its gross appearance alone. If the wound appears clinically clean, it may be closed by delayed suture and a pressure dressing applied; and healing approaching 100 per cent may be anticipated.

## SUMMARY

Clinical observations on two series of patients with a total of over 1,700 traumatic wounds have been presented in an effort to emphasize some of the pertinent factors influencing wound repair. These factors have included (1) a correct concept of débridement; (2) the hazard of secondary wound infections; (3) the indications and advantages of delayed suture; (4) the use and abuse of wet dressings; (5) the importance of pressure dressings; (6) the desirability of immobilization; (7) the value of blood replacement and (8) a re-emphasis of the role of adequate protein levels in wound repair.

Most of these observations are based upon military surgical experience. On the other hand, it appears to us that the same fundamental principles of management apply to any traumatic wound regardless of whether it is military or civilian in origin. It is admitted, however, that the extent of the application of those principles may differ in the two types of wounds. The time lag, extent, magnitude and location of the wound, as well as the environment of the patient and the type of clothing worn at the time of wounding are all pertinent factors which will influence the extent of the débridement. Furthermore, these same factors will decide whether the wound may be closed by primary suture or left open until a localized immunity has developed and then closed by delayed suture.

If these fundamental principles and pertinent factors are constantly borne in mind, it is the opinion of the authors that the surgeon or physician responsible for the care of traumatic wounds will be rewarded by less infections, less disability and a much earlier return of the patient to his usual employment.

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#### DISCUSSION

HOWARD E. SNYDER (Winfield, Kan.): I have enjoyed this paper very much. I think it should be said that the report you have just heard is probably unique in that shortly before the termination of the African campaign, Dr. Lowry set about to do an accurate follow-up on the cases that had received care by himself and his brother and several other surgical teams in southern Tunisia. The comparison of that early group with a later group is certainly a good one.

The points he has enumerated are certainly fundamental in war surgery and do not need further emphasis. I would like to have Dr. Lowry's opinion as to whether he still believes that vaseline gauze is the best material to place in the wound which is left open after débridement. In the latter months of the war it became the practice with many of us to employ fine-mesh gauze without vaseline. It was the impression of the base surgeons in our area that these wounds came back in even better shape than did those in which vaseline gauze had been used.

It might also be emphasized that the use of sulfonamide in the open wound was entirely discontinued in our theatre.

VINTON E. SILER (Cincinnati, O.): The subject of the treatment of traumatic wounds covers much territory. I would like to ask Dr. Lowry one ques-

tion, if he believes that many of these fundamental principles which he has stressed in war wounds should be carried over into civilian practice. We have believed that primary closure of wounds in civilian life is the method of choice rather than to close open wounds secondarily which could have been initially managed by primary closure.

KENNETH F. LOWRY (closing): I want to thank Dr. Snyder and Dr. Siler for their comments.

In answer to Dr. Snyder's question regarding the use of vaseline gauze, I will admit that I have continued to use it. However, I insist that it be very lightly impregnated with vaseline.

With reference to the use of sulfanilamide locally I realize that it fell into some disrepute and was officially discontinued by the Army Medical Corps. This is perhaps not the time or place to get into an argument over that; however, I admit that I am still rather partial to the use of sulfanilamide in small quantities in the freshly débrided wound. As a supplement to systemic therapy I believe that it puts the chemotherapeutic agent where it is most needed. When properly applied it has not, in our experience, interfered with tissue repair.

In answer to Dr. Siler's comment, as you know, several years ago Reid and Carter advocated the excision *en bloc* treatment of traumatic wounds. I believe that this procedure is very good and very satisfactory in superficial wounds. However, in wounds associated with considerable trauma and wounds that are quite deep we do not use it. You will note that there is a considerable excision of skin necessary and, as I previously pointed out, the skin is particularly resistant to infection. I believe you can visualize that if this procedure is followed, the danger of injuring major nerves and blood vessels which may be lying at the depth of the wound is rather obvious. If, however, one can use this type of excision *en bloc* procedure in a fairly superficial traumatic wound primary suture is, of course, justified. The method of débridement which we described is, of course, a procedure of piece-meal excision of traumatized and devitalized tissue. It is accomplished within a potentially if not actually infected tract and, therefore, has no pretention of being an aseptic operation. It insists on the exposure of the full extent of the wound tract thus minimizing possible injury to vital nerves or blood vessels.

We believe that in many wounds encountered in civilian life primary suture can be safely accomplished if you keep the patient under constant observation afterward, a situation which rarely exists in war. However, we still insist that these wounds associated with marked tissue destruction, contamination or a prolonged time lag are more safely handled by delayed suture.

# TREATMENT OF HUMAN BITES OF THE HAND\*

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REPORTS on the treatment of human bites of the hand have shown variations in the results. This paper analyzes the treatment of sixty-eight patients, some of whom were handled during the sulfonamide period and some during the penicillin era. An attempt is made to compare the results. This report does not purport to be a comprehensive review of the pathology of the subject as that was adequately covered in the classical paper of Mason and Koch.<sup>1</sup>

Certain features of the pathology and bacteriology cannot be too often re-emphasized as constant recognition of these facts leads to an appreciation of the magnitude of the problem and thence to rational therapy. The two authors pointed out that bacteria introduced through a knuckle of a clenched fist are carried well back up the hand as the tendon extends. The close interrelation of the hand spaces allows us to visualize the chain of events that frequently follow. Boyce<sup>2</sup> in an analysis of seventy-two cases pointed to the sites of spread in the order of frequency, namely, subcutaneous space, subfascial space, subaponeurotic space, metacarpophalangeal joints, fascial spaces of the palm and flexor tendon sheaths.

The bacteria commonly found in these lesions are *Staphylococcus aureus* and *albus*, the *Streptococcus* (viridans and micro-aerophilic), *Bacillus proteus*, *B. subtilis*, the fusiform bacillus and *Spirochete* of Vincent. Meleney<sup>3</sup> in discussing Boland's paper<sup>4</sup> placed great stress on the importance of the anaerobic streptococcus in these lesions. Just what has been the magnitude of this problem? The high incidence of radical surgery necessary in the collected cases presented by Welch<sup>5</sup> in 1936 shows the seriousness of the spread of infection. In presenting these cases Welch classified them as early, delayed and late. The early cases were patients seen within twelve hours of injury. The delayed were patients seen from twelve hours to a week. Late cases were those patients seen over a week from injury. (Table 1.) In this group the bacterial content did not

appear to bear any direct relationship to the severity. Each of the organisms mentioned above was fairly well distributed throughout the series.

Cohn<sup>6</sup> pointed out that in twenty-eight early collected cases one arm and two finger amputa-

TABLE 1\*

Total Cases	Early	De- layed	Late
Cases healed.....	5	9	7
Amputated finger.....	1	7	4
Amputated finger and metacarpal	..	2	
Amputated hand.....	..	1	
Amputated arm.....	1	1	
Died, sepsis.....	..	2	
Flail finger.....	1	1	
Stiff finger.....	1	1	
Left with osteomyelitis.....	1	..	1
Good function, recurrent sepsis...	..	..	1

\* From WELCH, C. E., Human Bite Infections of the Hand. *New England J. Med.*, 215: 901, 1936.

tions were done. In fifty-six delayed cases one hand and fifteen finger amputations were done. In twenty-three late cases nine fingers were amputated.

On the brighter side of the picture Bates<sup>7</sup> reported 100 cases in which the patients were treated by electrocautery without complications. As Welch pointed out these results are hard to evaluate as no details are presented.

Miller and Winfield<sup>8</sup> in an excellent presentation gave their results of treatment in sixty-one cases (early). (Table II.) The authors pointed out that these patients were all started on treatment before four hours. In these cases the average wound-healing time was 8.5 days. The last twenty-seven of these cases were particularly studied; in these the average healing time was 9.9 days. The authors then presented fifty-four late cases showing multiple infections of joints, fascial spaces and tendon sheaths. The average patient hospital time was 9.4 days; the total healing time was thirty-four days. In

\* From the Surgical Department, Philadelphia General Hospital, Philadelphia, Pa.



the latter group of cases considerable surgery was required. In the former it was negligible.

As one studies this question of human bites the aforementioned record in handling these cases is hard to beat. It is a testimony to the value of close attention to surgical principles.

TABLE II\*

Location of Injury	Cases (No.)	Re-mained Clean	Mild Inflammation	Gross Infection
Compound fracture, finger.....	6	5	1	0
Finger.....	34	32	2	0
Knuckle.....	18	15	2	1
Palm.....	1	1	0	0
Dorsum.....	2	2	0	0
Total.....	61	55	5	1

\* MILLER, H. and WINFIELD, J. M. Human bites of hand. *Surg., Gynec. & Obst.*, 74: 153, 1942.

The treatment in these cases was very similar to that to be described.

For purposes of discussion our own seventy cases were broken down according to the typing of Welch<sup>2</sup> as previously mentioned. A second classification was made, namely, those before sulfonamides, those treated with sulfonamides and those handled by penicillin. Two other factors enter in here. Some of the patients who received penicillin received sulfonamides in addition. Then, too, an awakened interest in these cases led to closer attention to the surgical principles mentioned hereafter.

Our case material was derived from two sources, namely, from the Police and Fireman's Ward and from the general surgical ward. Twenty-eight cases comprised the former group and the remainder comprised the latter group.

Measuring the success of treatment in this latter group has been difficult. This particular point should be stressed. The importance herein lies in the fact that many reports in the literature give the patient's number of hospital days on a certain type of therapy but do not report what happens to the patient after he leaves his inpatient status and goes out to clinic for follow-up care. It is a well known fact that many patients of the type handled in a city-hospital clinic are satisfied simply when their pain is relieved. They are patients who do not seek medical care until the pain is unbearable. Usually they are kept in the hospital until the progression of the infection is controlled; then

they are referred to the clinic for further dressing. Many of the wounds are still draining or granulating but are painless. A large percentage of these patients do not come back to the clinic. Attempts to follow this group find that they have either changed their address or are not interested. Not the least factor, however, is the fact that the shifting clinic personnel loses contact with the case early and fails to indoctrinate the patient in the habit of coming back for checkups. A plea might well be made here for the city hospitals which see most of these cases to establish a good follow-up on a large group of these cases. Such figures would help to establish a relatively standardized method for handling these cases.

#### TREATMENT

During the sulfa period intermittent hot soaks and elevation were the rule. Under the present regimen the affected hand is washed with soap and water. The wound is irrigated with large quantities of saline and left wide open. Any ragged edges are débrided. The hand and forearm are securely wrapped on a volar splint. Sterile gauze pads are placed over the region of the laceration and are moistened with saline. The splinted forearm is now placed on a half-ring splint and hung up to an intravenous standard at 45 degrees. (Fig. 1.) Additional comfort is added if a sandbag is placed beneath the upper arm. A hot water bottle one-quarter full is hung down off the intravenous standard onto the dorsum of the hand; then the whole splint is wrapped with a plastic wrapper to contain the moisture and the heat. (Fig. 2.) The patient is thus maintained on strict bedrest for forty-eight hours at which time the process is re-evaluated as to necessity for further immobilization. Adequate sedation must be given to offset the patient's impatience with bedrest.

Penicillin has been given preferably in large doses, i.e., 100,000 units every three hours. This large dosage was chosen after the question of penicillin-fastness had arisen in a few of the earlier cases tried with smaller doses to make the over-all actual dosage 63,000 units per three hours. Future figures are desired to see whether smaller doses will be as good. Not enough cases have been tried with the one shot per twenty-four hours technic to warrant any conclusions whatever.

The series of pre-sulfa cases here is too small to be of significance. One interesting point that



FIG. 1. Sustained and comfortable elevation is assured by the use of the splint. Further comfort is promoted by the use of a sandbag under the upper arm.

FIG. 2. The forearm and hand are shown snugly approximated to the protected basswood splint by gauze. The hand and fingers are covered by fluffed gauze into which a sterile catheter is threaded. In actual use the hot water bottle is wrapped with towel then encased by the plastic wrapper shown.

it does bring out is that some of the late cases just happen to be associated with bacteria of low virulence and are not necessarily crippling as are some of the more sweeping infections. These patients were abruptly sent to the outpatient department.

Although Table III shows a considerable improvement in the number of hospital days, this column does not tell the entire story. The vast majority of the patients who received penicillin went out completely healed. A few patients sent out while wounds were granulating raised the average of the clinic days. Reference to the average number of clinic days under the sulfa period makes the improvement under penicillin more dramatic.

Tables IV and V show without comment the distinct improvement along all lines during penicillin regimen.

The one finger amputation under the delayed penicillin group was performed on an alcoholic who was discharged as improved for further dressings in the clinic only to show up in a few weeks with a necrotic finger requiring amputation. Eight of these patients were cauterized before coming to the hospital.

The role of cauterization is questionable. It

is true, as previously mentioned, that Bates<sup>7</sup> reported in 1931 100 cases in which patients were treated by electrocautery. In this report he stated that their hospital did not have to admit any patient for human bites of the hand since 1925. In Table VI, however, are several patients severely enough infected after cauterization to require hospitalization. They did not develop any severe spreading complications. Measuring these cases against the rapid healing with bland soaks, immobilization and penicillin, we do not see the indication for cauterization.

Seventeen of these cases were sutured at other hospitals as well as here. This is mentioned only to be condemned. The greatly increased frequency of severe complications with suturing is well shown in Table VII. The relatively high number of wounds sutured indicates a lack of appreciation of the type of wound. It is well known that the victim in these cases is liable to lie about the origin of the wound and lead the physician away from realizing that it is a human bite. It will be noted that very few wounds have been sutured recently. Most of these occurred during the sulfa era. It is realized that this factor may have been a large contributor to the poor

TABLE III  
COMPARISON OF RESULTS OBTAINED WITH SULFA AND PENICILLIN

	Pre-sulfa			Sulfa Period			Penicillin Era		
	Early	Delayed	Late	Early	Delayed	Late	Early	Delayed	Late
No. cases.....	3	2	3	10	16	3	9	20	4
Average time before started treatment.....	?	?	?	7.7 hr.	2.3 days	17 days	6.2 hr.	1.7 days	12 days
Average number hospital days.....	1	39	4.6	6.15	11	30	3.8	6.5	18
Average number clinic days in followed-up cases.....	..	..	...	29	29	.....	7	10.6	

TABLE IV  
COMPARISON OF COMPLICATIONS IN SULFA AND PENICILLIN ERA

	Pre-sulfa			Sulfa Period			Penicillin Era		
	Early	Delayed	Late	Early	Delayed	Late	Early	Delayed	Late
No. cases.....	3	2	3	10	16	3	9	20	4
No. complications.....									
Osteomyelitis.....	..	..	..	2	1	3	0	1*	2
Thenar space infection.....	..	..	..	3	..	1	0	1	
Tendon slough.....	..	..	..	1	1	1	0		
Purulent arthritis.....	..	1							

\* Penicillin not begun until thirteenth day; sulfa up to that time.

TABLE V  
COMPARATIVE NEED FOR SURGERY IN SULFA AND PENICILLIN ERA

	Pre-sulfa			Sulfa Period			Penicillin Era		
	Early	Delayed	Late	Early	Delayed	Late	Early	Delayed	Late
No. cases.....	3	2	3	10	16	3	9	20	4
No. operations.....									
Incision and drainage.....	..	2	1	2	5	1	0	2	1
Finger amputation.....	..	..	..	0	0	0	0	1*	0
Metacarpal amputation.....	..	..	..	2	1	1	0	0	1

\* Penicillin not begun until thirteenth day.

average in the tables for the sulfa period and that maybe the difference is not as attributable to penicillin as we think. More reports on this subject are necessary.

#### CONCLUSIONS

1. The results of treatment of seventy cases of human bites of the hand are analyzed.

TABLE VI  
PATIENTS TREATED BY CAUTERIZATION BEFORE  
COMING TO PHILADELPHIA GENERAL HOSPITAL

Classification	Type Cautery	Hos- pital Days	Complica- tions	Out- come
Early sulfa.....	?	3	Other than local sepsis —o	Good
Early sulfa.....	Electro	6		
Delayed sulfa.....	AgNO <sub>3</sub>	7		Good
Delayed sulfa.....	Phenol	4 Av. 4		Good
Delayed sulfa.....	Electro	2		Good
Delayed sulfa.....	Phenol	3		
Early penicillin.....	Phenol	1		
Delayed penicillin....	?	3		

TABLE VII  
NUMBER OF PATIENTS SUTURED

Classification	Hos- pital Days	Clinic Days	Complica- tions	Outcome
Pre-sulfa early.....	1	13	(Other than local sepsis)	
Pre-sulfa early.....	1	12	None	
Pre-sulfa delayed....	2	30		Restricting scar Amputation
Sulfa early.....	30	6 wk.	Osteomyelitis of phalanx and meta- carpal	
Sulfa early.....	2	30		Restricting scar Flexion dis- ability
Sulfa delayed.....	8	6 wk.	Purulent Ar- thritis	?
Sulfa delayed.....	2	?	?	?
Sulfa delayed.....	4	6 days		Restricting scar
Sulfa delayed.....	30	?	Osteomyelitis of phalanx	Painful but good func- tion
Sulfa delayed.....	1	?	?	?
Sulfa delayed.....	4	?	Tendon slough	?
Sulfa delayed.....	4	?	None	
Sulfa delayed.....	10	?	?	
Sulfa delayed.....	8	?	?	?
Penicillin delayed....	3	?	?	?
Penicillin delayed....	5	?	?	?

2. We agree with Miller and Winfield that the most important single factor in handling human bites of the hand is to resort to the most scrupulous observation of surgical principles in the case of hand infections as outlined by Kanavel<sup>9</sup> and others.

3. Penicillin in adequate dosage combined

with the aforementioned renders *early* cases of human bites of the hand almost innocuous.

4. There is still not the general appreciation of the seriousness of these human bites and of the necessity for hospitalization. This is true of hand infections in general. More emphatic teaching on this point is necessary.

5. Suturing of these wounds is condemned.

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#### DISCUSSION

VINTON E. SILER (Cincinnati, O.): Dr. Grimes has given us a very excellent presentation of human bite infections and I agree for the most part with everything he has said.

The biggest problem in the care of this condition is to teach the house staff, particularly the admitting service of the hospital, the necessity for seeing these patients as soon after admission to the receiving unit as possible to direct therapy from that point.

One of the greatest problems is to send these patients home without any therapy whatever. The majority of our human bite infections are in patients who are under arrest and have been taken back to jail only to return to the hospital some forty-eight to seventy-two hours later with a very serious infection of the hand.

I might say one word about chemotherapy. Unquestionably it should be given, particularly penicillin, at the rate Dr. Grimes has mentioned. Along with it we would certainly advocate using streptomycin. There are reasons to believe that chloromycetin will help control these infections even better.

I think there must be some distinction made with regard to the depth of the initial wound. Those that penetrate the capsule of the metacarpophalangeal joint are much more serious in our own hands than those that just penetrate the skin.

JOSEPH POSCH (Detroit, Mich.): I would like

to say that I enjoyed Dr. Grimes' presentation very much. I would like to outline briefly the treatment of our hand injuries at the Detroit Receiving Hospital.

As has been mentioned, the patients are often seen very early and at that time a thorough washing is done for at least fifteen to twenty minutes. At the conclusion of that period the wound is débrided according to the depth of the injury. The superficial areas are débrided and left open. It was mentioned in Dr. Grimes' paper that they should not be sutured, and we would like to re-emphasize that point.

Recently we had a patient who was admitted with a severe infection of the back of his hand. He had a small laceration that had been sutured. He denied suffering a human bite of any type, but on going into his history we found that he had been in a scuffle. How he became injured he did not know. Clinically, it looked exactly like a human bite. This required thorough opening in the operating room under a tourniquet and brachial block anesthesia; at the present time he still has a residual arthritis.

Another case I would like to mention just briefly is a patient who had a seven-day old neglected human bite of the thumb. He was admitted with a superficial abscess plus a thenar space abscess. He developed periosteomyelitis and eventually had an ankylosis of his thumb, with a resulting three months' unemployment.

I think a comment on the use of electrocautery is interesting. We have used no cautery and do not think it is indicated. We have not been using zine peroxide, either, as mentioned by some authors. We are inclined to use a simple method such as thorough débridement and thorough washing.

Just one more point: I think a metal splint is always necessary for these for adequate immobilization. Because of insufficient hospital beds our early patients have not always been hospitalized but have been followed-up very carefully in the clinic and have been given seventy-two-hour penicillin twice weekly.

HARRY MILLER (Allentown, Pa.): I would like to point out the importance of early treatment of human bites. It is our belief that a human bite twelve hours old is already a late human bite. Unfortunately they usually came to us late.

In 1939 at the Detroit Receiving Hospital Hand Clinic under the direction of Dr. Chas. G. Johnston, Dr. Spears, Dr. Winfield and I studied the prophylaxis of human bite infections. It was our belief that in order to prevent the later complications and sequelae of human bites it was essential that these patients be seen and treated immediately. Thereupon, it became the duty of the resident on service to report to the admitting room and see these patients personally and direct their therapy.

The original treatment was that of shaving the surrounding skin, washing the surrounding areas of the wound for about five minutes and then continuing the soap and water washing for a full ten minutes. That was followed by limited débridement. If there had been penetration into the joint or laceration of the tendon or compound fracturing of the metacarpal, hospital admission was urged. Débridement was done in the operating room under general anesthesia following which the hand was splinted in a functional position and the patient returned to the ward where magnesium sulfate, Dakin's solution, boric acid or saline soaks were continued. If the patient was not admitted, treatment as outlined was carried out and the patient was advised to return to the hand clinic where he was seen within twenty-four hours. If evidence of infection was found at this time, the patient was admitted to the hospital for definitive treatment.

We believe that if the patient is seen within four hours, fewer patients will develop these sequelae and fewer will require hospital admission.

HARVEY S. ALLEN (Chicago, Ill.): Before the war, from 1938 to 1941, we had seen 327 human bites. Now we have changed our opinion a little with regard to the bites in the so-called antibiotic area. In the first place I think we should clarify what we mean by human bite. When we deal with a human bite that is only in soft parts, skin, subcutaneous tissue—incidentally we have had them all over the body, for example, the breast, face, leg, buttock, the tips of the finger—we are dealing only with a mixed but virulent infection. We have no closed spaces.

However, we still have our poor results in a wound of the actual fist-fight type in which a person may knock out a tooth and think he is the winner yet end up with a small ulcer over the metacarpal joint where the joint has been penetrated. If the soft parts only are involved, we have found that by the use of proper antibiotics, immobilization and, above all, hospitalization, our time is greatly reduced. In most cases in which the joint is involved we are still having complications of suppurative arthritis, adjacent osteomyelitis, fusion of the joint and often a stiff, useless finger.

We started first with anticipating that the hand would be stiff and, in using Kanavel's dictum of position or function, we anticipate that fusion may occur. We do not have the excellent findings of Dr. Grimes' but I am sure our hospitalization has been greatly shortened.

To reiterate, however, we are still very much depressed over the results that we are getting in those cases in which the joint cavity has been invaded.

EDGAR L. GILCREEST (San Francisco, Calif.): Wounds caused by human bites have interested me since my early days in Texas. As all of you perhaps know, that is a very common type of wound with

the negro. In a Saturday night fracas if a negro has forgotten his razor, he resorts to his teeth.

I remember so well a negro who was brought before the Court. The judge, looking at this poor negro and observing how he had been mutilated, turned to the other Negro, the defendant, and said, "In all my long experience I have never seen a human being so mutilated. When you tore open this man's mouth, the devil must have told you to do so. No human being could have thought of such a thing. When you flattened out his nose and gouged out his eye, the infernal demons must have been whispering to you." And the judge went on and on; but instead of the defendant becoming mortified, he became more and more proud. When the judge had finished, he said, "Yes sah, jedge, you're just 'xactly right. When I tore open his mouth, I could hear the devil telling me to do it; and when I flattened out his nose and gouged out his eye, I could hear the infernal demons whispering to me; but when I bit off his left ear, jedge, that was just *my own idea!*"

JOHN C. A. GERSTER (New York, N.Y.): That was a perfectly marvellous paper. I think from it we surgeons could take a good bit of advice regarding accidental wounds of our own and of our assistants in the operating room. I have seen some terrible infections, almost crippling ones, in surgeons old and young who disregarding an accidental puncture by a knife, sharp retractor or needle when operating in an infected area and failing to put the injured finger immediately at rest, went on operating with this infected puncture of their own finger which went on being massaged by the manipulations incidental to completion of the operation.

At one clinic abroad the minute an operator was accidentally injured he was sent away from the table and had his injured hand immobilized for from twenty-four to forty-eight hours. The chief of this clinic had lost one of his favorite assistants from sepsis of this sort. And so it is something we might bear in mind—the great principle of immediate rest as a safeguard against spreading of infection. Nowadays we have the sulfonamides and all the antibiotics but it is still well to stress the

principle of rest as beautifully as Dr. Grimes has stressed it.

LEWIS C. MANGES (closing): For many years this type of wound has been causing us a great deal of trouble among the policemen of Philadelphia. Dr. Hubley Owen, formerly the Police Surgeon of Philadelphia and a member of this organization, stimulated my interest in this injury. Although we believe that we are now able to treat this type of wound satisfactorily, as time goes on we may find that our problem is not completely solved. Dr. Allen states that he is still having trouble in spite of the more modern treatment. For a while we thought that excising these wounds and doing a primary suture was the best method of treatment. For approximately a year we had very little trouble and then we found a great deal of it. After Meleney's paper we attempted to use zinc peroxide. This, as proved by many people, was not the answer to the problem.

Dr. Miller, we have trouble getting these cases in four hours. In spite of our educational program among policemen, we have been unable to impress them with the seriousness of this injury. It is usually well past the four-hour period before they first present themselves in our Clinic. When we first seriously faced this problem, we tried three methods of combatting it. First, we tried to educate the policemen that this was a hazardous injury which should be treated immediately. This was of little avail. We then tried to educate the interns in the hospitals of Philadelphia that this was a special injury which should be given special treatment. This worked for a while until the interns were changed and we soon had the same trouble. The interns insist upon either suturing the wound or cauterizing it with silver nitrate, nitric acid or actual cautery. Dr. Bates' paper did not help us very much in Philadelphia. I think he was sincere in his paper but we could not substantiate his results. We still receive patients that have been cauterized before they are sent to our Police Clinic. Since we have been using penicillin, we have had very good results, particularly when treated as Dr. Grimes has described.



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# The American Journal of Surgery

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A PRACTICAL JOURNAL BUILT ON MERIT

Fifty-eighth Year of Publication

VOL. LXXVIII

DECEMBER, 1949

NUMBER SIX

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## Editorial

### PERITONITIS IN THE AGED

**E**LDERLY patients should not be condemned to die because they are judged too old for surgical treatment. Complications such as peritonitis to which aged patients are subject differ only in degree from those of others. However, more careful preoperative study is required taking into account the physiologic state of the body and extrinsic factors affecting the body's degenerative processes rather than the chronologic age.

In the aged the progress of infection is hastened by enfeebled circulation, senile emphysema, atrophy of lymphoid tissue and decrease in the formation of antibodies. The general resistance of the aged is depressed by arteriosclerotic changes, cardiac diseases, numerous nutritional disorders, local conditions, such as prostatic hypertrophy and a despondent mental attitude toward life.

Peritonitis causes death in the aged in the same manner as it does in the younger group and this is either by profound or overwhelming toxemia or by chemical and nutritional changes which accompany the associated small intestinal obstruction. If persistent leakage from a hollow viscus does not exist and if toxemia and obstruction can be controlled, the death rate could be maintained at a minimum.

Peritonitis can be grouped into three classes: the first due to perforations of the

gastrointestinal tract thereby including lesions of the gallbladder, stomach and intestine; the second group due to spread of a mixed infection from a primary source such as an acute suppurative appendicitis; and the third group due to rapidly spreading invasion of the peritoneum by virulent organisms.

In the first group if there is persistent leakage from a perforated viscus, the patient will not survive unless the leakage is closed within a reasonable period of time. The presence of gas in the peritoneal cavity will give conclusive evidence of the presence of a perforation. Unless the perforation appears to be sealing off and the peritonitis localized, or unless the leakage such as in a perforated peptic ulcer can be controlled with continuous gastric suction, the indications for surgical intervention are clear.

In the second group if the general condition of the patient is good, leakage of a perforated appendix is in most cases never progressive. The problem is then control of a localized infection by organisms which are apt to be virulent and resistant to antibiotics. However, with advancing years the structure of the appendix changes, the lymphoid tissue has largely disappeared and fibrous atrophic changes associated with vascular changes are present that cause an inability of the circulation to



respond to the demands of inflammation. Hence the devitalized appendix subject to the obstruction of its lumen by a fecolith soon perforates and, as the omentum and peritoneum frequently lack ability to localize the infection, general peritonitis usually ensues without classic signs or symptoms.

As for the third group, that is peritonitis caused by pneumococcus or streptococcus, the condition responds to chemotherapy and antibiotic agents so quickly that the final outcome is uneventful in most patients.

Postoperative peritonitis presents other problems. In these patients it is necessary to decide whether infection is due to leakage or the result of contamination. The problem is rendered more difficult because the presence of air in the peritoneal cavity is expected and does not help to establish the diagnosis of perforation. Secondary operations except for simple drainage or possibly ileostomy are rarely undertaken in these patients because it is often quite difficult to establish the diagnosis. One has to resort to gastrointestinal decompression, antibiotics, chemotherapy and general supportive measures.

Generally speaking there is still no specific treatment for acute peritonitis. The successful outcome is dependent on early diagnosis with prompt and judicious surgical intervention aided by chemotherapy and judicious preoperative care.

Preoperatively some consideration should be given to the maintenance of nutritional balance since the store of essential food substance is low; particular attention should be given to blood proteins, protein maintenance and vitamins. Cardiac incompetence should be studied and reserve in tissue functions carefully considered. The anesthetic should be chosen which will produce minimal visceral damage and I firmly believe inhalation anesthesia should be avoided whenever possible. The operation should not be unduly long and whenever possible minimal surgery should be done; however, one should not hesitate to carry out the proper surgical procedure

when indicated simply because of the individual's age. One must always bear in mind that greater gentleness is necessary in these patients since their tissue is much more easily injured by minor trauma.

Intestinal obstruction has been perhaps the most important contributory factor in causing death from peritonitis. The Miller-Abbott tube has been of great help in attempting to overcome this factor. The postoperative abdominal distention with loss of large quantities of fluid and electrolytes into and from the gastrointestinal tract, disturbances in nutrition, protein metabolism and in acid base equilibrium are all potent factors in bringing about the unfavorable outcome. Today many of these factors can be prevented or controlled and obstruction should be a rare cause of death.

The two most important considerations in passing a Miller-Abbott tube are the foresightedness of the attending surgeon and perseverance of the house surgeon to whom details are entrusted. The time for passing such a tube is also important. If the tube is passed before operation and intestinal intubation is instituted successfully, one of the major problems of peritonitis is under control. If it is delayed until the patient is greatly distended, too ill to cooperate and the ileus is so far advanced that the bowel has lost its tone, the tube may be difficult to pass and the effects of intubation will be doubtful.

Fluid and electrolyte balance is a problem that requires serious consideration. If the plasma proteins and cardiac reserve are normal, there is little danger of giving enough fluid to cause cardiac decompensation or pulmonary edema; however, one must always keep in mind that the vessels of old people respond less rapidly and readily to changing conditions. If the urinary output is about 1,500 cc. or more a day and if the patient does not have chronic nephritis, there is little danger of giving too much salt unless all fluids are given in saline. Administration of excessive amounts of saline causes retention of salt with consequent retention of water and

disturbance in acid base equilibrium. Any blood chloride deficiency should be corrected promptly.

The frequency with which hypoproteinemia occurs in the aged has been demonstrated repeatedly. The condition may exist in the absence of edema. Even minor degrees of hepatic damage may be reflected in lowered levels of blood proteins. Many investigators have called attention to the important part that protein metabolism, particularly hypoproteinemia, plays in wound healing, predisposition to shock, postoperative edema in wounds, increased susceptibility to infection and hepatic dysfunction. It is therefore essential that an attempt be made preoperatively to increase protein reserves and postoperatively to maintain a positive nitrogen balance.

As for the control of infection it was not until the introduction of sulfonamides and antibiotics that we had any specific means of controlling pyogenic infections. Penicillin when used in large amounts is effective in controlling peritonitis due to mixed infection. By giving enough penicillin over a long period of time eventually more penicillin is given than the *Escherichia coli* can destroy or inactivate and finally a sufficient concentration of active penicillin is built up to inhibit the growth of the offending virulent cocci.

Sulfanilamides when administered in effective doses are valuable adjuncts in the treatment of these patients. They are used intravenously until tolerated by mouth and at all times should be used in combination with penicillin and streptomycin.

Clinical experience and experimental data indicate that the use of streptomycin is not as effective as the use of penicillin, particularly when the latter is used in combination with sulfadiazine. Streptomycin appears to be of the greatest value in the treatment of early spreading peri-

tonitis. It should be used early, and in combination with penicillin and sulfadiazine.

Reports on the use of aureomycin appear favorable, however, this agent is still in the investigative stage.

If one reviews the usual cases of peritonitis in the aged it will be found that the mortality rate had been exceedingly high before the advent of the sulfa drugs and antibiotics. One will also note that mortality is still high in spite of the use of newer drugs. An analysis of the poor results will disclose the following: (1) Operations on seriously ill individuals are usually undertaken too late. (2) Operations are not performed because clinical signs of peritonitis found in these patients are not classic. (3) The general preoperative condition of older patients is not usually very good. (4) The elective removal of a diseased gallbladder or diseased appendix will sometimes prevent the possibility of peritonitis subsequently due to an acute cholecystitis or acute appendicitis. (5) Exploratory laparotomies should be done more frequently on the equivocal case of suspected intra-abdominal infection in the aged. (6) Surgical consultation should be sought early in any case of suspected intra-abdominal infection in an old person.

In general it may be stated that surgical aggressiveness should be encouraged in the management of these cases and successful management can be hoped for, I reiterate, only if (1) early diagnosis is made; this is at times most difficult in the aged because the signs and symptoms are not classic; (2) early surgical intervention is undertaken, with careful preoperative and postoperative care; (3) effective surgical intervention is undertaken; by this is implied that while the surgery be minimal it should also be definitive in spite of the age of the patient and (4) effective chemotherapy and adequate supportive measures are used.

THOMAS C. CASE, M.D.



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# Original Articles

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## MECKEL'S DIVERTICULUM\*

### A REVIEW OF THIRTY-NINE CASES

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IN reviewing the literature on Meckel's diverticulum some interesting facts concerning its historical aspects are found. One author states that Littré in 1700 described a structure that was probably a true congenital diverticulum. Another states this was reported by Littré in 1742 which would be sixteen years after his death. One author reports Ruysch as observing this anomaly in 1701 yet another states, with a variation in spelling, that a Ruysch made this observation in 1707. However, the literature goes on to tell us that Meckel was the first to publish an adequate description of this anomaly in 1809, 1812 or was it 1815? Some observers mention a Berlin anatomist, Johann Fredrick Meckel, but he died in 1777. Others mention a Johann Fredrick Meckel of Leipzig who was born in 1781 and, as near as can be figured out, must have been the grandson. At any rate the persistence of the duct connecting the midgut with the yolk sac in early embryonic life may lead to the formation of what is known as Meckel's diverticulum.

The literature on this subject has been very extensive, particularly during the late twenties and early thirties. During the past several years there seems to have been a revival of interest in this important anomaly, particularly because of the surprisingly high percentage of Meckel's diverticula showing serious pathologic complications. Then, too, it is said to be the most common anomaly of the entire intestinal tract.<sup>6</sup> Too many cases (2 to 3 per

cent) have been reported at routine post-mortem examinations and not enough at the time of surgery. We agree with Umphrey, who reported Meckel's diverticulum occurring only nine times in 3,460 intra-abdominal operations, that many cases obviously have been missed. Balfour reported only fifteen Meckel's diverticula in 11,107 abdominal operations. McGlaurman reported only three cases in 14,000 laparotomies. In our own series of thirty-nine cases covering thirty-three years seventeen of the cases were found during the past ten years and during 1948. When an increased effort was made to uncover some of these cases at surgery, seven were found. It is the purpose of this paper to present a review of the thirty-nine cases encountered at the Jackson Clinic. Particular emphasis will be placed on the pathologic complications and also on the importance of carefully searching for this anomaly at intra-abdominal operations.

*Age and Sex Incidence.* In our series Meckel's diverticulum occurred twice as often in males as in females (twenty-six and thirteen) which is in agreement with most observers. Interestingly enough six of seven of the 1948 cases occurred in females. Possibly in the future the sex incidence will be more equally divided.

Excluding the youngest patient, age ten months, and the oldest, age seventy-two, the average age was twenty-five years. The age group fourteen to twenty-one represents the most cases (ten) followed by the seven to fourteen group (eight).

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*Pathologic Complications.* Forty-six per cent of the diverticula were incidental, that is, without disease. Fifty-three per cent or twenty-one cases showed pathologic changes. This incidence is considerably higher than that generally reported in the literature. We have grouped the different types of pathologic conditions according to Haber's classification. (Table 1.)

#### INFLAMMATORY TYPE

The preoperative diagnosis of Meckel's diverticulum is rarely made because the symptoms vary according to the type of diverticulum found. Also, acute diverticulitis is said to be rare because usually the opening of the diverticulum in the ileum is large, the contents liquid and the contents will empty simultaneously with the ileum. In this series, however, eleven cases showed inflammatory changes, seven being acute or gangrenous. Of these, three diverticula perforated with resulting peritonitis. Symptoms of this type usually resemble those of an inflamed viscus or a perforated viscus and simulate acute appendicitis or a perforated appendix.

#### CASE REPORTS

**CASE I.** No. 78136, a male, age fifty-one, was admitted to the hospital with the chief complaint of pain in the abdomen. The onset of the pain had been twenty-three hours prior to his admission and had begun as a sharp, knife-like pain in the right scrotum. The patient was unable to continue his chores about the farm because of the pain which caused him to double up. He felt nauseated but did not vomit. In lying down the pain became less severe. The patient spent a fairly comfortable night and in the morning noticed a dull, aching pain in the right lower quadrant. He attempted to milk a cow and the pain became worse, so the patient sought medical aid. There had been no previous episode of this nature but twelve years before the patient stated he had a large amount of intestinal bleeding and was treated by his local doctor. He received a blood transfusion and was confined to bed at home for three months because of weakness.

Physical examination revealed a moderately dehydrated, acutely ill patient in apparent

distress. The head, neck, heart and lungs were essentially normal. The abdomen was moderately distended with tenderness most marked in the right lower quadrant. No masses were present. His temperature was 100.5°F., pulse 100 and respirations 28; blood pressure was 108/80. The hemoglobin was 80 per cent and the white blood count 17,950. A preoperative diagnosis of acute appendicitis was made.

The abdomen was explored under spinal anesthesia through a right pararectus incision. On opening the peritoneum a lemon yellow exudate was encountered. The loops of small bowel were densely adherent and it was impossible to identify the cecum or colon. The entire intestines were covered with a thick, chronic, inflammatory caul. Dissection of the main inflammatory mass revealed a ruptured Meckel's diverticulum. This was resected and the abdomen was drained and closed in layers. The patient's postoperative convalescence was stormy for the first six days and then improved. He was discharged on the twenty-first day.

It was thought that this patient apparently had a massive hemorrhage and widespread peritonitis from the Meckel's diverticulum twelve years before and on this admission suffered from an acute diverticulitis with perforation and another generalized peritonitis.

**CASE II.** No. 48280, a female, age seventy-two, complaining of severe generalized abdominal pain and vomiting of two days' duration, was brought to the hospital by her local doctor. Two days before admission she was up and about doing her housework when she was suddenly seized with a stabbing abdominal pain followed by vomiting. The pain remained constant and appeared to be located in both lower quadrants. There had been no previous acute attack but the patient stated she had abdominal cramps with occasional vomiting and constipation for about ten years.

Physical examination revealed a markedly dehydrated, acutely ill patient with an ashen gray complexion; she appeared toxic. Her temperature was 101.6°F., pulse 120 and respirations 28. The white blood count was 18,000. Physical signs and symptoms were limited to the abdomen which was greatly distended, rigid and diffusely tender throughout. Pelvic examination revealed a large, tender, fluctuating mass in the posterior cul-de-sac. A preoperative diagnosis of pelvic abscess due to a ruptured appendix was made.

TABLE I

Case	Age	Sex	Year	Abdominal Pain	Vomiting	Melena	Hemoglobin (Per cent)	Duration of Symptoms	Preoperative Diagnosis	Postoperative Diagnosis	Pathologic Findings	Treatment	End Result
18071	10	M	1915	Yes	Yes	Yes	...	3 yr.	Intestinal hemorrhage	Meckel's diverticulum with perforating ulcer	Meckel's diverticulum inflamed 20 inches from ileocecal valve; perforating ulcer	Resection of bowel with side-to-side anastomosis	Recovery
14845	48	M	1916	Yes	No	No	...	6 mo.	Acute appendicitis	Appendicitis and acute diverticulitis	Appendicitis and acute diverticulitis	Appendectomy and resection of diverticulum	Recovery
21845	19	M	1920	Yes	No	No	85	8 mo.	Chronic appendicitis	Acute Meckel's diverticulum	Acute Meckel's diverticulum	Appendectomy and resection of diverticulum	Recovery
20602	25	M	1921	Yes	No	No	...	6 mo.	Chronic appendicitis	Same with Meckel's diverticulum	Retrocæcal appendix. Meckel's diverticulum 18 in. from ileocecal valve	Appendectomy and resection of diverticulum	Recovery
34321	25	M	1923	Yes	Yes	No	...	3 da.	Intestinal obstruction	Same due to Meckel's diverticulum	Normal appendix; Meckel's diverticulum 36 in. from ileocecal valve and adherent to proximal bowel by adhesions	Bowel freed and raw surfaces covered with omentum graft; Meckel's diverticulum not removed	Recovery
34693	44	M	1924	Yes	No	No	85	4 mo.	Chronic appendicitis	Same with Meckel's diverticulum	Appendix subacutely inflamed; tip of Meckel's diverticulum acutely inflamed	Appendectomy and resection of Meckel's diverticulum	Recovery
48072	14	F	1926	Yes	Nausea	No	80	7 da.	Subacute appendicitis	Subacutely inflamed Meckel's diverticulum	Meckel's diverticulum subacutely inflamed 18 in. from ileocecal valve; appendix normal	Appendectomy and resection of Meckel's diverticulum	Recovery
48380	72	F	1926	Yes	Yes	No	...	10 da.	Pelvic abscess due to ruptured appendix	Generalized peritonitis due to ruptured appendix	Rupture of base of Meckel's diverticulum with abscess formation and peritonitis	Resection of Meckel's diverticulum and drainage of abdominal cavity	Death (19th post-operative day)
49850	14	M	1926	Yes	No	Yes	15	4 da.	Intestinal hemorrhage due to Meckel's diverticulum	Same	Meckel's diverticulum 16 in. from ileocecal valve with bleeding ulcer	Appendectomy and resection of Meckel's diverticulum	Recovery
53276	27	M	1927	Yes	No	No	90	14 da.	Chronic appendicitis	Same with Meckel's diverticulum	Subacute appendix and non-inflammatory Meckel's diverticulum	Appendectomy with resection of Meckel's diverticulum	Recovery
37895	52	M	1929	Yes	No	No	85	1 yr.	Chronic appendicitis	Subacutely inflamed Meckel's diverticulum	Meckel's diverticulum 18 in. from ileocecal valve; non-inflammatory	Appendectomy with resection of Meckel's diverticulum	Recovery
58631	29	M	1929	Yes	Yes	No	88	3 da.	Acute appendicitis	Same with Meckel's diverticulum	Acute appendix; Meckel's diverticulum 12 in. from ileocecal valve non-inflammatory	Appendectomy with resection of Meckel's diverticulum	Recovery
45105	28	F	1930	Yes	No	No	87	25 da.	Chronic appendicitis	Same with Meckel's diverticulum	Appendix subacutely inflamed; Meckel's diverticulum not inflamed	Appendectomy with resection of Meckel's diverticulum	Recovery
70524	33	M	1931	Yes	No	Yes	65	3 yr.	Intestinal hemorrhage due to Meckel's diverticulum	Same	Meckel's diverticulum 20 in. from ileocecal valve with ulceration	Resection of 6 in. bowel with side-to-side anastomosis	Recovery
69229	18	M	1931	Yes	No	No	97	14 da.	Acute appendicitis	Subacute appendicitis; subacute diverticulitis	Same	Appendectomy and resection of Meckel's diverticulum	Recovery
78136	51	M	1933	Yes	No	Yes (12 yr. ago)	...	1 da.	Acute appendicitis	Ruptured Meckel's diverticulum with generalized peritonitis	Ruptured Meckel's diverticulum with generalized peritonitis and dense small bowel adhesions	Resection of Meckel's diverticulum and drainage	Recovery
76125	10 mo.	M	1933	Yes	Yes	No	...	1 da.	Intestinal obstruction	Intestinal obstruction due to Meckel's diverticulum	Tip of Meckel's diverticulum adherent to lower iliac mesentery; 18 in. of ileum were gangrenous	Excision of Meckel's diverticulum and exteriorization of gangrenous bowel	Death (1st post-operative day)
65603	8	M	1933	Yes	Yes	No	80	1 da.	Acute appendicitis with early peritonitis	Ruptured Meckel's diverticulum and generalized peritonitis	Gangrenous Meckel's diverticulum with perforation and generalized peritonitis	Appendectomy; resection of Meckel's diverticulum and abdominal drainage	Recovery
72750	33	M	1933	Yes	No	No	...	1 yr.	Chronic appendicitis	Same with Meckel's diverticulum	Retrocæcal appendix; Meckel's diverticulum not inflamed	Appendectomy and resection of Meckel's diverticulum	Recovery
83114	21	M	1935	Yes	Yes	No	...	21 da.	Acute appendicitis	Acute Meckel's diverticulum; acute mesenteric lymphadenitis	Acutely inflamed Meckel's diverticulum 13 in. from ileocecal valve; mesenteric islands enlarged	Appendectomy and resection of Meckel's diverticulum	Recovery

84735	12	F	1935	Yes	No	No	...	1 yr.	Subacute appendicitis	Same with Meckel's diverticulum	Appendix subcutely inflamed; Meckel's diverticulum 13 in. from ileocecal valve; mesenteric glands enlarged	Recovery
89688	12	M	1937	Yes	Yes	Yes	30	15 mo.	Intestinal hemorrhage due to Meckel's diverticulum	Same	Meckel's diverticulum 24 in. from ileocecal valve with bleeding ulcer at tip	Recovery
73180	19	M	1938	Yes	Yes	No	...	1 da.	Strangulated incisional hernia	Incarcerated incisional hernia; Meckel's diverticulum	Meckel's diverticulum 24 in. from ileocecal valve with bleeding ulcer at tip	Recovery
80721	43	M	1938	Yes	No	No	70	1 yr.	Chronic cholecystitis with cholelithiasis	Same with Meckel's diverticulum	Meckel's diverticulum not inflamed	Recovery
93044	20	F	1938	Yes	Yes	No	78	1 yr.	Subacute appendicitis	Same with Meckel's diverticulum	Appendix subcutely inflamed; fecoliths; Meckel's diverticulum 12 in. from ileocecal valve; not inflamed	Recovery
100179	24	F	1940	Yes	No	No	103	21 da.	Chronic appendicitis	Same with Meckel's diverticulum	Chronic appendicitis; Meckel's diverticulum not inflamed	Recovery
108849	36	M	1942	Yes	No	No	...	1 da.	Acute appendicitis	Subacute appendicitis and Meckel's diverticulum	Subacute appendix; Meckel's diverticulum 15 in. from ileocecal valve; not inflamed	Recovery
109009	19	M	1942	Yes	No	No	...	1 yr.	Subacute appendicitis	Same with Meckel's diverticulum	Appendix subcutely inflamed; Meckel's diverticulum	Recovery
99710	16	M	1942	Yes	Yes	No	...	30 da.	Intestinal obstruction due to postoperative adhesions; appendectomy done elsewhere 2 weeks before	Intestinal obstruction due to Meckel's diverticulum	Small bowel obstruction due to volvulus caused by Meckel's diverticulum attached to umbilicus	Recovery
117318	32	M	1943	Yes	No	Yes	80	Melena 16 yr. before	Intestinal hemorrhage due to Meckel's diverticulum	Same	Meckel's diverticulum 12 in. from ileocecal valve; marked scarring and induration with 1½ mm. ulcer at base	Recovery
127014	8	F	1945	Yes	No	No	80	6 da.	Acute appendicitis	Mesenteric lymphadenitis and Meckel's diverticulum	Normal appendix; enlarged mesenteric glands; Meckel's diverticulum 10 in. from ileocecal valve not inflamed	Recovery
126552	55	M	1947	Yes	No	No	...	2 mo.	Chronic cholecystitis	Same and Meckel's diverticulum	Chronic cholecystitis with lithiasis; Meckel's diverticulum 18 in. from ileocecal valve; not inflamed	Recovery
69439	23	M	1948	Yes	Yes	No	90	1 da.	Acute appendicitis	Meckel's diverticulum 15 in. from ileocecal valve subcutely inflamed	Meckel's diverticulum subcutely inflamed; appendix acutely inflamed; normal	Recovery
69530	17	F	1948	Yes	No	No	90	2 da.	Acute appendicitis	Meckel's diverticulum 18 in. from ileocecal valve subcutely inflamed	Meckel's diverticulum subcutely inflamed; gastric mucosa	Recovery
69624	30	F	1948	...	...	...	...	.....	Diastasis recti	Same and Meckel's diverticulum	Meckel's diverticulum 36 in. from ileocecal valve; not inflamed	Recovery
71227	30	F	1948	Yes	Yes	No	88	3 yr.	Acute appendicitis	Mesenteric lymphadenitis and Meckel's diverticulum	Mesenteric glands enlarged; Meckel's diverticulum 30 in. from ileocecal valve; not inflamed	Recovery
152941	21	F	1948	Yes	No	No	94	1 da.	Acute appendicitis	Same with Meckel's diverticulum	Acute appendix; Meckel's diverticulum 8 in. from ileocecal valve; not inflamed	Recovery
136951	17	F	1948	Yes	No	No	80	1 da.	Acute appendicitis	Same and Meckel's diverticulum	Acute appendix; Meckel's diverticulum 18 in. from ileocecal valve; not inflamed	Recovery
141474	18	F	1948	Yes	Yes	No	80	10 da.	Acute appendicitis	Subacute appendicitis and Meckel's diverticulum	Subacute appendix; Meckel's diverticulum 15 in. from ileocecal valve attached to umbilicus	Recovery



FIG. 1. Photograph of surgically resected Meckel's diverticulum and appendix. Case No. 65603.  
FIG. 2. Cut section revealing presence of enteroliths. Case No. 65603.

On the day of admission a posterior colpotomy under nitrous oxide was done which released a large amount of foul-smelling, purulent material. The patient showed some improvement during the following two weeks but her temperature continued to spike and the foul drainage became increasingly profuse. Fifteen days later the abdomen was explored under ether anesthesia through a lower right rectus incision. The lower ileum and sigmoid were plastered with a purulent exudate underlying which were rather dense adhesions. Freeing of the adhesions caused severe wall perforations of the sigmoid which were immediately sutured. In the left lower quadrant there was a large perforation of the base of a Meckel's diverticulum. The diverticulum was resected and the bowel was closed. The appendix was small and fibrosed. The abdomen was closed in layers and a cigarette drain inserted. The patient had a stormy postoperative course and gradually became weaker and weaker until she expired on the sixteenth postoperative day. The cause of death was generalized peritonitis due to a ruptured Meckel's diverticulum. No post-mortem examination was obtainable.

CASE III. No. 65603, a boy, age eight, was admitted to the hospital complaining of generalized abdominal pain and vomiting. The night before admission the patient had eaten four apples before going to bed. Shortly thereafter he had severe abdominal cramps and could not sleep. Three hours later he became nauseated and vomited. He had several bouts of vomiting before his admission. The pain became less acute and on admission he complained

of pain in both lower quadrants. Past history was non-contributory.

Physical examination revealed a fairly well hydrated but acutely ill patient. His temperature was 101.8°F., pulse 120 and respirations 32. The head, neck, lungs and heart were essentially normal. The abdomen was moderately distended with acute tenderness in both lower quadrants. Moderate rigidity was present in both lower quadrants but was more pronounced on the right. Rectal examination was non-revealing. The white blood count was 18,200. A preoperative diagnosis of acute appendicitis with early peritonitis was made.

The abdomen was explored under spinal anesthesia through a small McBurney incision. Opening of the peritoneum revealed about 500 cc. of serosanguineous fluid lying free in the abdominal cavity. The appendix was congested and covered with a fibrinous exudate. A perforated Meckel's diverticulum was found 18 inches from the ileocolic valve. The diverticulum was approximately 4 inches long with an enlarged terminal bulbous end which contained many large enteroliths. The gangrenous portion of this end had perforated. The diverticulum was resected, an appendectomy done and the wound closed in layers with a penrose drain inserted to the fascia. (Figs. 1 and 2.) The patient's postoperative convalescence was uneventful and he was discharged on the eleventh postoperative day.

CASE IV. No. 83114, a boy, age seven, entered the hospital complaining of pain in the abdomen and vomiting. The onset of pain had been twenty-six hours prior to his admission and began with stomach cramps while he was

playing outdoors. He vomited about an hour later. Pain continued as a dull ache and the patient vomited several times throughout the night after the ingestion of water. His mother stated that two years before he had a similar but less severe attack.

Physical examination revealed an alert, well developed, well nourished boy who did not appear to be in acute distress. Temperature was 99°F., pulse 124 and respirations 20. The white blood count was 20,150. The head, neck, lungs and heart were without significant changes. The abdomen was flat but somewhat resistant. Palpation of the right lower quadrant revealed acute tenderness. Rectal examination was negative but high palpation on the right elicited tenderness. The preoperative diagnosis was acute appendicitis.

The abdomen was explored under spinal anesthesia through a right pararectus incision; a small amount of free, straw-colored fluid was encountered on opening the peritoneum. The appendix appeared to be normal. An acutely inflamed Meckel's diverticulum was found 13 inches from the ileocolic valve. The mesenteric glands were numerous and enlarged. An appendectomy and resection of the diverticulum were done and the abdomen was closed in layers. The patient made an uneventful recovery and was discharged on the fourteenth postoperative day.

#### OBSTRUCTIVE TYPE

The symptoms of the obstructive type are the same as those of any other bowel obstruction. Haber and others state that the most numerous pathologic changes resulting from Meckel's diverticulum are of the obstructive type. This has not been true in our series. Intestinal obstruction is brought about in a number of ways. There may be torsion of a volvulus, intussusception knotting around the intestine, bands and remnants of the omphomesenteric ducts and vessels, and incarceration in a hernia. Haber diagrammatically shows the different types of obstruction and describes in detail five cases representing the types of small bowel obstruction due to Meckel's diverticulum. Meckel's diverticulum occurs occasionally in connection with inguinal, umbilical and femoral hernia. Probably 50 per cent or less are incarcerated. Patterson

in a recent review of the literature reports twenty-one cases of incarceration of Meckel's diverticulum in a femoral hernia and adds another case for a total of twenty-two. Atwood has reviewed the literature on intussusception due to an invaginated Meckel's diverticulum and reports an additional case. Following is a review of two of the obstructive cases encountered in our series.

CASE V. No. 76125, a male infant, aged ten months, was admitted to the hospital with the history of apparent abdominal pain and vomiting fourteen hours prior to admission. The night before entering the hospital the baby appeared to be in perfect health. He romped about the floor and was entertaining visitors. At 11:00 P.M. the infant awoke crying violently. He vomited and preferred lying on his side doubled up. A local doctor was called who examined the baby and prescribed treatment. At this time the abdomen was slightly distended but not rigid. The next morning the infant was again seen at which time the abdomen was moderately distended. No abdominal mass was felt. A rectal examination revealed some formed stool present but no blood or mucus. The child was pale and listless and was brought to the hospital. A flat film of the abdomen revealed rather advanced distention of loops of small bowel in the left abdomen. The cecum and transverse colon did not appear distended. A 2-ounce enema of hydrogen peroxide and sodium bicarbonate was given. There was an immediate expulsive effort and a formed stool 4 to 5 inches in diameter was evacuated. The baby seemed to brighten up at once and looked better. Hot stupes and subcutaneous fluids were administered. Within the next two hours the abdominal distention increased, there was no passage of gas or stool per rectum and the baby again appeared pale and listless. Surgery was decided on at once. A preoperative diagnosis of intestinal obstruction probably due to Meckel's diverticulum was made.

Under spinal anesthesia (20 mg. novocain) the abdomen was explored through a right rectus incision. The terminal end of a Meckel's diverticulum was adherent to the lower iliac mesentery. Eighteen inches of terminal ileum from the ileocecal junction to the site of the Meckel's diverticulum was black and gan-





FIG. 3. Photograph of Meckel's diverticulum with loops of gangrenous bowel (post mortem). Case 76125.

grenous. (Fig. 3.) The diverticulum was excised, the gangrenous bowel with the cecum was exteriorized and the bowel was opened for drainage. The immediate postoperative condition of the infant appeared satisfactory. Four and a half hours later the infant suddenly expired. A postmortem examination which was limited to the operative incision only revealed what had been seen at surgery. It was believed, however, that death was due to a pulmonary embolus.

CASE VI. No. 99710, a boy, age sixteen, was admitted to the hospital complaining of abdominal pain and vomiting of three days' duration. Twelve days before his admission he had an appendectomy done elsewhere. His immediate postoperative convalescence was uneventful but on the tenth day his abdomen became distended, he vomited and had colicky pain. He had a small, difficult bowel movement. The vomiting continued on the eleventh and twelfth postoperative day and the parents stated the vomitus was dark brown with a fecal odor. There was no bowel movement the past two days.

Physical examination revealed an acutely ill sixteen year old boy who appeared markedly dehydrated. His temperature was 99°F., pulse 96 and respirations 28. The blood pressure was 140/90. The head, neck and chest showed no abnormality. The abdomen was distended and rigid. Tenderness was present in both upper quadrants; intestinal sounds were hyperactive and high-pitched. No masses were palpable. An open film of the abdomen showed a stepladder

configuration of the small bowel indicating a low small bowel obstruction. The white blood count was 6,100, hemoglobin 112 per cent and red blood count 6,320,000. The urine specific gravity was 1.031, blood urea 84 mg. per cent and blood chlorides 375 mg. The patient was given intravenous fluids and was prepared for surgery. The preoperative diagnosis was small bowel obstruction due to postoperative adhesions.

The abdomen was explored under spinal anesthesia. The recent right rectus incision was reopened and slightly enlarged. On opening the peritoneum there was free escape of a moderate amount of free fluid transudate. Loops of small bowel were distended to about 2½ inches in diameter. The distended bowel was mahogany colored but not gangrenous. Peristalsis was visible below the point of obstruction which was 24 inches from the ileocecal valve. At this distance a large Meckel's diverticulum was found which remained attached to the umbilicus. A loop of ileum had become attached to the inflamed wall of the diverticulum and had rotated about the umbilical attachment causing the obstruction. Below the diverticulum the small bowel was adherent and kinked due to adhesions, causing further obstruction. The diverticulum was freed at its umbilical attachment and the volvulus untwisted. The adhesions were severed and the diverticulum was resected with the use of a Furniss clamp. A Wetzel type ileostomy was done and the abdomen was closed in layers. The patient ran a septic temperature for the first few postoperative days and then proceeded to complete recovery.

This case certainly emphasizes that any time a surgeon opens an abdomen and explores the lower quadrants for disorders in the absence of an acute infection he should examine at least 3 feet of terminal ileum and search for Meckel's diverticulum.

#### PEPTIC ULCERATION

The complications of peptic ulcer (ectopic gastric tissue) in Meckel's diverticulum is the same as in any other peptic ulcer, namely, bleeding and perforation. Intestinal hemorrhage is the most constant symptom. The blood may be either bright red, maroon or tarry but is usually maroon. Clots may be present but mucus is absent. Intestinal cramping should lead

one to suspect the diagnosis of Meckel's diverticulum. With minimal ulceration and the passage of an occasional tarry stool the diagnosis may be more difficult. Peptic ulceration in this anomaly is said to be an affliction of infancy or childhood. Messenger and Collins believe that no age group is immune. They report nine cases of intestinal hemorrhage, four of the patients being under four and a half years of age and five from seventeen to sixty years of age. Arnold Jackson in 1926 reported the first acute case of intestinal hemorrhage due to an ulcer of a Meckel's diverticulum. The patient was a boy, age fourteen, whose predominating symptom was the passing of bright red blood per rectum.

In the differential diagnosis of these cases intussusception must be ruled out. In intussusception a smaller amount of blood is passed and there is usually an admixture of blood and mucus. A mass can usually be palpated abdominally or by rectum. There is obvious evidence of intestinal cramping and pain occurs paroxysmally every few minutes.

CASE VII. No. 49850,\* a boy, aged fourteen, was admitted to the hospital with the chief complaint of repeated massive intestinal hemorrhage of four days' duration. The patient was seized with severe generalized abdominal cramps following the eating of green apples a few days previously. A physician was called who treated him for green apple colic. The boy was relieved of the pain with sedatives but became progressively weaker. On the third day considerable bright blood containing many clots was passed from the rectum. Another physician was called. He observed the further passage of several pints of blood varying in color from maroon to bright red. Noticing the marked anemia, progressive weakness and absence of general physical signs, except for slight tenderness in the right lower quadrant, he was vividly reminded of the clinical picture of a similar case he had seen two years previously and made a diagnosis of intestinal hemorrhage from Meckel's diverticulum.

On admission to the hospital physical examination revealed an acutely ill, very pale, sixteen

year old boy who was in shock. His pulse was 128, very weak, temperature 100°F. and respirations 20. Hemoglobin was 12 per cent and the red blood count 1,210,000. The head, neck and chest showed no abnormality. The abdomen was flat, non-rigid and palpation elicited only slight tenderness in the right lower quadrant. The patient immediately received intravenous fluids and a whole blood transfusion of 500 cc. of citrated blood. The patient remained semi-comatose for two hours and gradually improved. The following day he again received a whole blood transfusion and his general condition improved greatly. Following further supportive measures the patient's blood picture continued to improve and he was up and around within a week. After the first twenty-four hours no further intestinal hemorrhages were seen. On the twelfth hospital day an exploratory operation was done.

The abdomen was explored through a sub-umbilical right rectus incision. On opening the peritoneum a small amount of straw-colored fluid was allowed to escape. The terminal ileum was located and about 40 cm. from the ileocecal valve a Meckel's diverticulum measuring 3 by 8 cm. was found. The terminal end was free and there was no visible or palpable evidence of hemorrhage. The appendix contained several fecal concretions and appeared edematous. No other pathologic lesions were found. The diverticulum was resected and an appendectomy was performed. The patient had an uneventful postoperative convalescence and was discharged on the tenth postoperative day.

Pathologic examination of the diverticulum showed the presence of the characteristic areas of gastric mucosa and an area of ulceration which was the site of the hemorrhage.

CASE VIII. No. 70524, a male, aged thirty-three, was admitted to the hospital with the chief complaint of bloody stools. While in the service in France during World War I he had an attack of intestinal flu associated with severe vomiting and blood-tinged stools. Following this he was well until three years before admission when he noticed a few tarry stools. He was examined but nothing was found to account for his trouble. He was well until three weeks before admission when he had similar dark stools and felt faint. He had no pain or abdominal distress. The morning he entered the hospital he had a very large bloody stool estimated at about 1 quart.

\* This case was previously reported by A. S. Jackson.

On admission to the hospital physical examination revealed a chronically ill, fairly well nourished white male. His temperature was 99.8°F., pulse 120 and respirations 22. The hemoglobin was 65 per cent, red blood cells 3,200,000, white blood cells 11,800, with 78 per cent neutrophils and 20 per cent lymphocytes. The head, neck and chest showed no abnormality. The abdomen was flat and there were no palpable masses. Pressure over McBurney's point elicited moderate tenderness. Bowel sounds were normal; rectal examination was negative. A proctoscopic examination revealed the lumen to be filled with dark red clots as far as the reach of the proctoscope. At roentgenologic examination no lesion was found in the gastrointestinal tract. The patient received a blood transfusion and other supportive treatment and was operated upon on his third hospital day. A preoperative diagnosis of intestinal hemorrhage due to Meckel's diverticulum was made.

The abdomen was explored under spinal anesthesia through a lower right rectus incision. The entire colon was found to be filled with dark, clotted blood. A nodular mass was found 20 inches from the ileocecal valve. The mass together with 9 inches of ileum was resected and a side-to-side anastomosis was done. Upon opening the specimen it was found to be a large Meckel's diverticulum with a large ulcer crater at its base. The abdomen was closed in layers. The patient made a very uneventful recovery and was discharged on the fifteenth postoperative day.

CASE IX. No. 117-318, a male, age thirty-two, was admitted to the hospital with the chief complaint of rectal bleeding. On the morning of his admission to the hospital he had a bowel movement and noticed bright red blood in the stool. The previous day he had experienced a stomach ache but no nausea or vomiting. He gave a history of previous rectal bleeding sixteen years before and again nine years before; neither of these episodes were serious enough to require hospitalization.

Physical examination revealed a well nourished, well developed male who did not appear acutely ill. His temperature, pulse and respirations were normal. The blood pressure was 140/60; hemoglobin was 80 per cent and the red blood count 4,200,000. Bleeding and coagulation time were normal. Examination of the head and neck was negative. There was a loud-

blowing, precordial systolic murmur heard loudest at the apex of the heart. Examination of the abdomen was negative. Rectal examination revealed the presence of clotted blood. A proctoscopic examination merely indicated that the bleeding was higher in the gastrointestinal tract. The patient was given five blood transfusions in the next ten days. On his fifth hospital day during a transfusion the patient had another severe rectal hemorrhage. His hemoglobin dropped to 65 per cent and the red blood cells to 2,800,000. The patient was given further supportive treatment by the use of koagamin (oxalic acid). The patient gradually improved and was discharged on his fifteenth postoperative day. He was instructed to return in ten days for x-ray studies of the gastrointestinal tract. These roentgenograms were negative and an exploratory operation was advised. The preoperative diagnosis was intestinal hemorrhage due to Meckel's diverticulum.

The abdomen was explored under spinal anesthesia through a pararectus incision. The appendix was mildly inflamed and was removed. Twelve inches from the ileocecal valve a firm cicatricial mass was found in the ileum. Closer examination showed an hourglass type of Meckel's diverticulum which extended  $1\frac{1}{2}$  inches into the mesentery. Because of the induration and scar tissue surrounding the diverticulum about 5 inches of ileum were resected and a side-to-side anastomosis was performed. Exploration of other abdominal organs was negative. The abdomen was closed in layers.

Pathologic sections (Figs. 4 and 5) showed a diverticulum composed chiefly of a gastric type of mucosa. In the smaller part of the diverticulum a chronic ulcer extended to the muscularis mucosa. The patient had an uneventful postoperative course and was discharged on the fourteenth postoperative day.

CASE X. No. 89688, a boy, aged twelve, entered the hospital complaining of the passage of bright red blood with loose bowel movements for the past four days. The patient and his mother stated that for the past fifteen months he had similar attacks at three- to four-month intervals. The attacks continued for three to four days and seemed to follow a definite sequence of events. The first day there would be a headache followed by vomiting; on the second day the passage of bright red rectal blood would be noticed with a semi-liquid



FIG. 4. Photograph of surgically resected Meckel's diverticulum showing cut section of mesenteric portion. Case No. 117318.

FIG. 5. Same specimen showing mucosal surface with chronic ulceration through the muscularis mucosa. Case No. 117318.

stool. On the third day the stool would be dark and remain so for a few more days and then clear spontaneously. Abdominal pain was usually not a symptom.

Physical examination revealed a very anemic and chronically ill-appearing boy. His temperature was 100.4°F., pulse 140 and respirations 22. The blood pressure was 94/60; hemoglobin was 30 per cent, red blood count 1,810,000, white blood count 8,540, with 84 per cent neutrophils and 14 per cent lymphocytes. Bleeding time was seven and a half minutes and coagulation time six minutes. The physical examination was entirely negative except for dark blood on the examining finger following a rectal examination. A proctoscopic examination was essentially negative except for the presence of black tarry fluid coming from above a 15 cm. level. The colon and small bowel on roentgenologic examination showed normal progress of the barium and no evidence of any pathologic lesions. The patient received several whole blood transfusions and other supportive treatment and was operated upon on his sixth hospital day. A preoperative diagnosis of intestinal hemorrhage due to Meckel's diverticulum was made.

Under spinal anesthesia the abdomen was explored through a right pararectus incision. The colon was filled with blood. Twenty-four inches from the ileocecal valve a Meckel's diverticulum measuring 3 by 1½ cm. was found. The base was indurated and on the mucosal surface an ulcer with evidence of recent hemorrhage was seen. (Fig. 6.) The diverticulum was resected at its base and the bowel closed transversely. The appendix appeared normal but was removed at the family's request. The wound was closed in layers. The

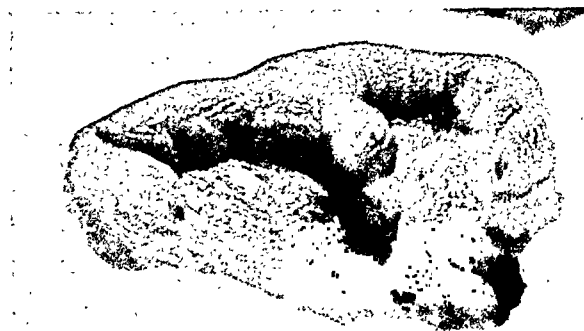


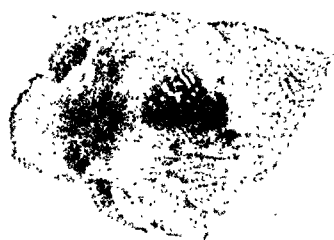
FIG. 6. Photograph of Meckel's diverticulum at operation prior to resection. Note ulcer with evidence of recent hemorrhage. Case No. 89688.

postoperative course was uneventful and the patient was discharged on the twelfth postoperative day.

#### TUMORS IN MECKEL'S DIVERTICULUM

Various types of tumors or tumor tissue have been found in Meckel's diverticulum. Excluding gastric and pancreatic heterotopic tissue, if they may be classified as tumors, the incidence of benign or malignant tumors is very low. Tumors may form from the normal cellular elements of the intestinal mucosa or more frequently from the aberrant tissue elements of gastric and pancreatic mucosa. The gastric type has been found in 15 to 30 per cent of all cases. The pancreatic type is found less frequently.

The literature contains isolated reports of benign tumors which include adenomas, myomas, lipomas, papillomas, neuromas, enterogenous cysts, carcinoids, etc. Car-



7

FIG. 7. Photograph of surgically resected enterogenous cyst within a Meckel's diverticulum. Case No. 93044.



8

FIG. 8. Cut section revealing tightly packed caseous material surrounded by chronic inflammatory changes.

cinoid or argentaffin tumors while found quite frequently in the appendix are rarely seen in Meckel's diverticulum. Less than ten cases of carcinoid tumors have been reported in Meckel's diverticulum. In our series, excluding those containing aberrant gastric mucosa, only one benign tumor was found.

Malignant tumors are rarely found in Meckel's diverticulum. In the carcinomatous group Costich and McNamara (1946) cite previously reported cases and add an additional case. Of these cases seven were adenocarcinomas and two were of the medullary type. In the sarcomatous group Nygaard and Walters found fourteen cases.

As mentioned previously the preoperative diagnosis of Meckel's diverticulum is rarely made and, if made, it is impossible to state that a tumor is present. The pathologic complications such as inflammation, obstruction, perforation, hemorrhage, intussusception, etc., occur in non-malignant lesions as well as malignant lesions and, of course, much more frequently.

No malignant lesions were found in our series.

CASE XI. No. 93044, a girl, aged twenty, was admitted to the hospital complaining of pain in the right abdomen, nausea and vomiting of twelve hours' duration. The pain began the previous morning. It was located in the right lower quadrant and was intermittent in character. The patient was nauseated and vomited several times. On admission the patient stated that the pain was steady and in the right lower quadrant. The past history revealed that she had seven similar episodes during the past year.

Physical examination revealed a well developed, well nourished white female who did not appear acutely ill. Her temperature was 99.2°F., pulse 80 and respirations 18. The blood pressure was 120/80 and the red and white blood counts were normal. The urinalysis also was normal. The head, neck, heart and lungs showed no unusual findings. The abdomen was flat, soft, without palpable masses and was slightly tender over McBurney's point. A pelvic and rectal examination was negative. A preoperative diagnosis of subsiding appendicitis was made. Because of her numerous previous episodes an appendectomy was advised.

The abdomen was explored through a right pararectus incision. The appendix was slightly inflamed and was removed. Exploration of the ileum revealed an occluded Meckel's diverticulum 2 by 4 cm. about 12 inches from the ileocecal valve. Two and one-half inches of the ileum were resected with the diverticulum intact and a side-to-side anastomosis was performed. Exploration of other organs revealed no additional disorder and the abdomen was closed in layers. The patient had an uneventful recovery and was discharged on the twelfth postoperative day.

The pathologic report revealed that the diverticulum was filled with an amorphous, inspissated material. At the mouth of the diverticulum the mucosa was entirely absent being replaced by tightly packed caseous material surrounded by chronic inflammatory changes. (Figs. 7 and 8.) In the distal two-thirds of the diverticulum the caseous material had dissected between the muscularis and circular muscular coats producing detachment and eversion of the mucosal lining of the diverticulum. The diagnosis was an enterogenous cyst within a Meckel's diverticulum.

Enterogenous cysts anywhere along the outer

gastrointestinal tract are very rare. A search of the literature does not reveal any of such cysts contained in a Meckel's diverticulum.

#### ANALYSIS

Thirty-nine patients with Meckel's diverticulum were operated upon by various members of the surgical staff of the Jackson Clinic during the years 1915 to 1948. The preoperative diagnosis was correct in four of the five cases showing intestinal hemorrhage. The earliest case (1915) was not diagnosed preoperatively.

Meckel's diverticulum occurred twice as often in males as in females (twenty-six and thirteen). The average age, excluding the youngest, aged ten months, and the oldest, aged seventy-two, was twenty-five years.

Forty-six per cent (seventeen cases) of the diverticula were without disease. Fifty-three per cent (twenty-two cases) showed pathologic changes. Contrary to what has previously appeared in the literature, our inflammatory group (eleven cases) was the most dominant rather than the obstructive group. Of seven of the acute or gangrenous cases three went on to perforation with resulting peritonitis. There were four obstructive cases. In the peptic ulcer group (six cases) five showed clinical evidence of intestinal hemorrhage.

Abdominal pain was present in every case except the diastasis recti case in which the diverticulum was an incidental finding. Intestinal hemorrhage or melena was found in six cases. Fourteen patients vomited one or more times.

Resection or excision of the Meckel's diverticulum was performed in thirty-five of the thirty-nine cases.

All the patients went on to recovery except the very youngest and the very oldest. The former had a gangrenous ileum and expired on the first postoperative day (1933). The latter had generalized peritonitis due to a perforated diverticulum and expired on the nineteenth postoperative day (1926).

December, 1949

#### SUMMARY

1. Some historical aspects are discussed.
2. The pathologic complications of Meckel's diverticula are reviewed.
3. An analysis of thirty-nine cases and a detailed description of eleven cases illustrating the various pathologic conditions are presented.
4. A search for Meckel's diverticulum should always be made during an intra-abdominal operation, especially when the gross appearance of the organ being investigated does not fit the clinical picture.

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# DEVELOPMENT OF TOTAL PNEUMONECTOMY\*

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TOTAL pneumonectomy as first performed seventeen years ago was far from exhibiting a work of fine or polished technic. If any merit attaches, it rests on the daring nature of the procedure; however, the requisite courage reflected more credit upon the patient than upon the surgeon.

After reporting this case I did not make it the object of further publications and, consequently, no follow-up report was published. Now the opportunity is presented to make up for this omission. However, it must be understood that as early as two years after the first pneumonectomy the technic performed in this case had become obsolete.

At any rate it may be interesting to students of the recent history of medicine to appreciate the surgeon's fears and doubts before such an extensive operation especially since the only three recorded previous attempts had been unsuccessful.

When I became Sauerbruch's associate in 1921 the situation was somewhat as follows: The great hopes arising from the development of methods to obviate the danger of an operative pneumothorax were not realized in respect of pulmonary resection. We soon learned that a successful outcome on these operations was due to an obliterated pleura which made reopening of the ligated bronchus more or less harmless. In fact, closure of the bronchus was the paramount problem and it was thought that the wisest policy might be to anticipate a separation of the bronchial stump.

It became a fixed rule that obliteration of the pleural leaves must precede a successful lobectomy and much inventiveness

was employed to produce this adhesive pleurisy. The hilum of the lobe was closed by placing an elastic tourniquet around the hilum or by mass-constricting ligatures waiting for the devascularized tissue to sequester. Thereupon the open lumen of the bronchus emptied its contents into a walled-off operative field.

The results of this cumbersome procedure were not too bad, the postoperative mortality of lobectomies being between 10 and 15 per cent.

In 1929 Harold Brunn published his paper on one-stage lobectomy in a free pleural space. From the practical and historical angle this represented considerable progress as was immediately realized in the Anglo-Saxon countries. However, the amazing results obtained by Brunn were not so much due to the particular handling of the hilum as to the institution of an intercostal subaqueous drainage in anticipation of a possible bronchial fistula. Thus removal of air and exudates and expansion of the remaining lobe were assured.

When the problem arose of removing an entire lung, we thought it was desirable to stick to the old method because of the accumulated experiences with this procedure in lobectomies. The problem, however, was not so much that of technic but of functional pathology. There was little concern as to the sudden loss of respiratory surface effected by pneumonectomy since traumatic surgery and collapse therapy had amply shown how well defunctionalizing of an entire lung is tolerated. There was more concern about the empty space left by the removal of an entire lung. To be sure, several cases of agenesis of one lung were

\* Read at the Historical Section of the American Medical Association meeting, 1948, at Chicago, Ill., on invitation by the Secretary who chose the title "The First Successful Pneumonectomy and its Historical Significance."



FIG. 1. X-ray picture taken after admission of the patient on whom the first successful total pneumonectomy was performed (Surgical University Hospital of the Charite, Berlin). Pressure pneumothorax on the left side with displacement of the mediastinum; mediastinal and subcutaneous emphysema.

FIG. 2. June, 1931, after the patient had recovered from the immediate consequences of the accident, a bronchogram was performed which revealed bronchiectasis of the entire left lung.

FIG. 3. X-ray picture taken six months after left total pneumonectomy (July 21, 1931); retraction of mediastinum toward the side operated upon, extreme elevation of the diaphragm and shrinking of the left thoracic cage.

reported in the literature and the authors had clearly explained the way in which by shifting of mediastinum, elevation of diaphragm and shrinkage of the corresponding thoracic cage this problem was solved. The greatest apprehension, however, centered around the sudden occlusion of the main branch of the pulmonary artery. The disastrous effect of pulmonary embolism was all too familiar to us and we knew that shutting off one of the main branches meant a high mortality.

A review of the literature on experimental pneumonectomy disclosed that the operation had been successfully performed on rabbits and dogs in many instances even as far back as 1881 and 1882 by Gluck and by Biondi. In these experiments the question of adequate bronchial closure and of provision for compensatory filling of the empty half of the chest by the remaining thoracic organs is widely discussed, particularly in papers of the later investigators, but the circulatory problem arising from the ligation of a main artery and the two veins is scarcely mentioned. This is justified, I think, because the common experimental animals do not respond to massive pulmonary embolism in the way human beings do probably because of the tremendous reserve power of their hearts.

#### CASE REPORT

The opportunity of attempting pneumonectomy presented itself to me in July, 1931. The patient, a girl twelve years of age, developed severe mediastinal emphysema following a crushing injury to the thorax. An immediate incision in the neck resulted in liberation of air through the incision. The simultaneous presence of tension pneumothorax suggested a tear in the left main bronchus. (Fig. 1.) Empyema of the left pleura developed and drainage was instituted.

During the course of several months the typical symptoms of chronic pulmonary suppuration developed. An abscess which presented in the third (left) intercostal space near the sternum was drained. The wound communicated with the left main bronchus. Lipiodol injected through the fistula demonstrated bronchiectasis of the entire left lung. (Fig. 2.) Bronchostenosis resulting from the injury to the main bronchus was the obvious cause of the pulmonary suppuration. Although the patient's general condition was not good, it was decided to extirpate the entire left lung.

The two possible operative procedures were either total pneumonectomy or multiple unilateral lobectomy. In favor of the latter was our comparatively large experience with lobectomy. However, in performing lower and upper lobectomy a considerable portion of infected and dilated bronchi at the hilum would have to be left behind because of the low level of





FIG. 4. Picture of the patient taken in March, 1932; the left axillary incision leading to a small fistula of the left main bronchus is visible. This fistula closed spontaneously shortly afterward.

dissection. Therefore, total pneumonectomy seemed to be the logical procedure with the understanding that the tourniquet should be placed as high on the hilum as possible.

After paralyzing the left diaphragm an axillary resection of the third to fifth rib was

erally, the upper lobe was freed. After the entire lung was separated, an elastic tube ligature was tied around the hilum proximal to the bronchial obstruction; and additional silk ligatures were placed peripheral to the elastic ligature. Gauze was again packed around the lung.

After operation the patient's temperature was elevated to 39°C. and the pulse rate varied between 140 and 160 for about a week. The necrotic lung sloughed away on the fourteenth day. The residual cavity decreased rapidly in size, being aided by the extreme rise of the diaphragm and the marked retraction of the mediastinum toward the side operated upon. (Fig. 3.) Accordingly, a thoracoplastic collapse to obliterate the pleural space was not necessary. After eight weeks only a small fistulous tract which led to the stump of the left main bronchus remained.

The patient was demonstrated on March 31, 1932, at the annual Convention of the German Surgical Society (Fig. 4) and by Sauerbruch in



FIG. 5. Picture of the patient taken six years later (1937).

performed. The extensive adhesions offered no difficulty in separation of the lung. After the pedicle of the lower lobe had been developed and while endeavoring to isolate the upper lobe, strong traction on the hilum resulted in temporary cardiac stoppage. The operation was discontinued and the entire wound was packed.

I believe it was fortunate that the cardiac arrest occurred before the tourniquet was placed because otherwise we would have attributed it to occlusion of the major blood vessels rather than to the actual cause, a vagal reflex.

The second stage was performed fourteen days later on July 21, 1931. Beginning periph-

April, 1934, before the same forum; the bronchial fistula had meanwhile closed spontaneously. The last picture of the patient was taken six years later in 1937. Her physical condition was excellent at this time; the left half of the chest showed signs of atrophy which was particularly evident in the different size of the breasts. (Fig. 5.)

After the conclusion of hostilities I was unable to obtain news from the patient who is said to live in the Russian Zone of Occupation in Germany.

The outstanding feature during the second operation was the absence of acute symptoms following mass ligation of the

hilum vessels. Not even signs of vagal reflex, which forced us to discontinue the first attempt, were present. In spite of the tachycardia which persisted for almost a week, there was never noticeable dyspnea; this is in marked contrast to what is experienced in pulmonary embolism.

Another observation in our case was later shown to be the rule rather than the exception, namely, the fact that in spite of a limited rib resection, the empty half of the chest was filled with the remaining thoracic organs.

One and a half years after this operation the second successful pneumonectomy was performed by Cameron Haight on a girl of thirteen suffering from diffuse bronchiectasis of the left lung. The technic used by Haight was essentially the same except that the level of mass ligation chosen by him was different. He thought it wiser to ligate the two lobes separately leaving more bronchial tissue behind. While in this case a similar stenosis of the main bronchus was present as in my own, no unfavorable effects were observed from the presence of the two remaining stumps. Haight's patient is the oldest living pneumonectomy subject in this country. She is now married, has one child, and is in excellent general condition. She has had no pulmonary symptoms since her discharge from the hospital sixteen years ago. (Fig. 6.)

The third successful operation, that of Evarts A. Graham, performed in April, 1933, has rightfully received much publicity because this time the pneumonectomy was done in one stage for carcinoma. When Haight and I ventured to remove a whole lung, it was our hope that surgical treatment of bronchogenic carcinoma might one day benefit from these experiences. The hope was quickly realized by Graham's brilliant operation and its splendid success. Graham's patient, a physician forty-eight years of age, today, fifteen years after the operation, is practicing and in the best of health. (Fig. 7.)

There was, however, one shortcoming in Graham's one-stage procedure. While it

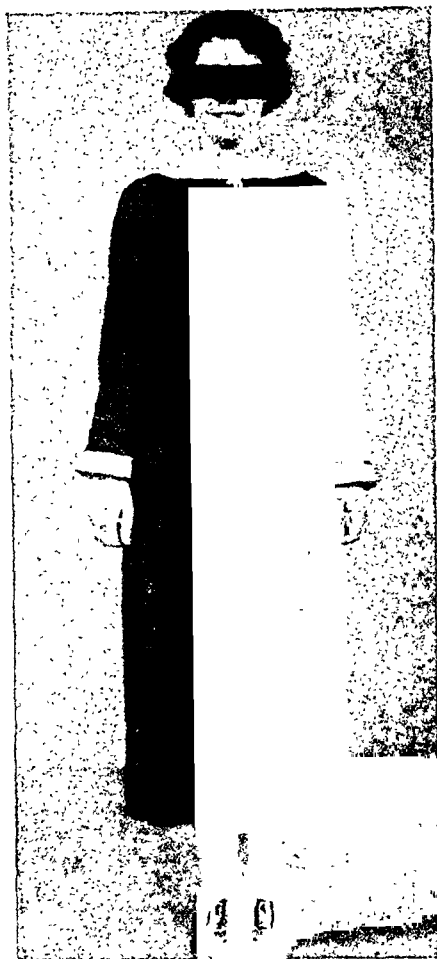


FIG. 6. Picture of Cameron Haight's patient twelve years after the left total pneumonectomy which was performed in 1932. (With the permission of Dr. Cameron Haight.)

was fully successful in his particular case, it must be assumed that by leaving behind a large intrapleural stump the majority of carcinomas of the main bronchus could not be dealt with adequately by this technic.

The turning point in the technical development of total pneumonectomy, particularly for bronchogenic carcinoma, is represented by Rienhoff's successful mediastinal dissection.

Individual ligation of the three main vessels and suture of the main bronchus as first done by him was in accordance with surgical principles established for other organs of the body. Rienhoff's operation, successfully performed in July, 1933, for fibrosarcoma in a child three and one-half



FIG. 7. Picture of the patient on whom Evarts A. Graham performed total pneumonectomy for bronchogenic carcinoma in 1933. (GRAHAM, E. A., SINGER, J. J. and BALLON, H. C. *Surgical Diseases of the Chest*. P. 843. Philadelphia, 1935. Lea & Febiger.)

years of age, concluded the experimental stage of total pneumonectomy.

In the fifteen years which have passed since then very little has been added to this technic which beside achieving perfect hemostasis permits fairly reliable closure of the bronchus, which none of the previous technics had achieved.

Regarding the significance of the first successful pneumonectomy, this operation may have encouraged other surgeons by demonstrating first, sudden and permanent interruption of half of the vascular pulmonary circulation in human beings is, as a rule, well tolerated; second, the empty space remaining after pneumonectomy is rapidly filled out by compensatory expansion of the other lung and by displacement of heart and diaphragm.

However, the great practical value the operation has attained today must be accredited to Rienhoff and I believe that the operation which I performed seventeen

years ago would never have justly been recorded in the textbooks of the history of medicine had not Rienhoff modified the operative technic.

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# AN INQUIRY INTO LATE POSTPARTUM HEMORRHAGE\*

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DESPITE the fact that late hemorrhage in the puerperium constitutes one of the most grave complications the obstetrician encounters and despite the fact that it requires keen diagnostic acumen and seasoned clinical judgment for its proper evaluation and correct management, there is remarkably little written on the subject. Other names for this complication are secondary puerperal hemorrhage, spätblutung and hemorrhage tardive. Isolated articles, consisting mostly of case reports, may be found in the French and German literature under the latter two titles. In contrast to the voluminous literature which was accumulated on the subject of immediate postpartum hemorrhage, aside from sporadic reports, there is practically nothing to be found regarding late puerperal hemorrhage, a complication just as serious if not even more treacherous than immediate postpartum hemorrhage.

The definition of late postpartum hemorrhage is entirely arbitrary. Kermauner<sup>1</sup> defined it as bleeding coming on twenty-four hours postpartum or postabortion, whereas Frankl<sup>2</sup> required that the bleeding not appear until at least a week after parturition or abortion to be considered under spätblutung. It has been my practice to regard the puerperium as lasting three months rather than just six weeks inasmuch as many patients have not completed the process of involution for approximately three months. Accordingly, the term late postpartum hemorrhage will be defined as any genital tract bleeding coming on after the first twenty-four hours of the puerperium postpartum or postabortion.

The seriousness of late postpartum hemorrhage is generally not appreciated.

Secondary hemorrhages are often sudden and massive and may be as exsanguinating and shocking as hemorrhage from placenta previa, placental ablation or severe atony immediately postpartum. On the contrary, each episode of late bleeding may be only moderate in amount but the bouts may recur frequently or the bleeding may be an almost continuous issue of blood which may go on for weeks although the amount lost on any one day may not be excessive. Secondary hemorrhage is particularly treacherous inasmuch as it often happens days or weeks after the patient has been dismissed from the hospital hence, the armamentarium for combating shock and hemorrhage is usually not immediately available in contrast to the facilities customarily in readiness in all well equipped hospitals for the treatment of immediate postpartum hemorrhage. It is usually very difficult for the attendant to explain an episode of late puerperal hemorrhage to the patient and her family; sometimes it is quite difficult for him to satisfactorily explain it to himself. In any event the usual reaction of the patient is the belief that the attendant is guilty of a sin of omission. On the contrary, however, careful inquiry into the causation of the majority of these instances of late bleeding establishes the fact that the complication was entirely unforeseeable and unavoidable.

The frequency of late bleeding is difficult to estimate. However, no less than 10 per cent of puerperal patients experience excessive bleeding after the first twenty-four hours. Usually, to be sure, the bleeding in the average case responds to a prescription of limited activities, more bed rest and a course of oxytocics. Nevertheless, in my

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experience somewhat more than 2 per cent of my puerperal patients have required additional active treatment for late bleeding. Therapeutic measures have included blood transfusion, curettage, tamponade, vaginal ligation of the uterine arteries, hysterectomy and ovarian cystectomy. From a wide obstetrical experience it has been Stephenson's<sup>3</sup> observation that the incidence of late postpartum hemorrhage has definitely increased in the last five to ten years despite the fact that he has not employed estrogens for the prevention or suppression of lactation and despite the fact that the percentage of mothers nursing their babies has not changed. One wonders whether or not the practice of earlier ambulation and the vogue of patients resuming full activities so soon after return home following delivery may be contributory factors in the definitely increased incidence of secondary bleeding.

Investigation of patients who bleed excessively in the puerperium usually discloses some local pelvic disorder as the etiologic factor; most commonly, retained fetal elements, evidence of faulty regeneration of the uterine mucous membrane or submucous myomas are found. Kermauner<sup>1</sup> classified his cases into four groups as follows: (1) retained placental tissue; (2) generalized infections; (3) aneurysms and (4) defective regression of the blood vessels in the uterine mucous membrane. However, before proceeding with an inquiry into the specific pelvic lesions which can cause late hemorrhage, it might be of interest to review the general systemic disorders which may evidence late postpartum hemorrhage as a salient clinical manifestation.

#### HEMORRHAGE DUE TO SYSTEMIC DISORDERS

*The Hypotonic Somatotype.* In his very provocative book, "The Autonomic Diseases," Rivers<sup>4</sup> devotes three most interesting pages to a discussion of the difference between the hypertonic, with predominant thoracolumbar autonomic system, and the hypotonic (vagotonic) obstetrical patient.

In speaking of the hypotonic type he says, "Some of this type hardly cease to menstruate during pregnancy, and they may have hemorrhages from the most trivial causes. Abortions are more frequent, and delivery sometimes results without pain; but the hemorrhages following delivery may be profuse and hard to control. They are not only susceptible to hemorrhage, but they are susceptible to shock, and every precaution must be observed to prevent unusual excitement which could cause shock, lest it bring sudden dilatation of the uterus and the vessels therein to result in fatal hemorrhage. Astringents have less pressor action on the uterus of this type and they need to be repeated more often. . . . While the tonic type requires special care to prevent toxemia, the hypotonic class requires special care to prevent hemorrhage."

I agree with Rivers that there is a hypotonic type of woman who is basically frail. Her blood pressure is usually subnormal or normal; she aborts easily; her labor is characterized by easy dilatation of the cervix; but she tends to have immediate postpartum hemorrhage from uterine atony and she seems prone to secondary hemorrhage during the puerperium. Whether all this is due to the vagotonia or whether the latter is simply part of the physiologic make-up of this constitutional type is not clear. In any event the hypotonic somatotype bleeds easily and sinks into irreversible shock from a blood loss usually not incompatible with life for certain other constitutional types.

*Blood Dyscrasias.* Secondary puerperal hemorrhage may be a manifestation of one of the hemorrhagic purpuras, aplastic anemia or leukemia. Thrombopenic purpura may be a disease *sui generis* or it may be secondary to infectious diseases (scarlet fever, tuberculosis, sepsis) or to the action of certain toxic or allergenic agents. Secondary purpura has followed the taking of iodine, bismuth, benzol and arsphenamine. Peshkin and Miller<sup>5</sup> have reported

the occurrence of purpura after the ingestion of ergot and quinine. Radiation therapy may induce hemorrhagic purpura by its depressant action upon the bone marrow just as metastatic tumor can cause it by myelophthisis. Rushmore<sup>6</sup> has reported thrombopenic purpura accompanying pregnancy and Minot<sup>7</sup> has described its association with menstruation. Menorrhagia may be the first and often the only symptom of thrombopenic purpura.

To cases of severe puerperal sepsis complicated by aplastic anemia Couvelaire<sup>8</sup> gave the name "metrorrhagic form of puerperal sepsis." Williams<sup>9</sup> reported such a case of desperate postpartum sepsis which ended fatally with hemorrhage late in the puerperium due to aplastic anemia. A fatal uterine hemorrhage on the eighth postpartum day was the termination of Mann's<sup>10</sup> case of pregnancy complicated by lymphatic leukemia.

From the aforementioned it is evident that one should always consider the possibility of blood dyscrasia in evaluating instances of secondary puerperal hemorrhage. A complete count, including platelets, bleeding and clotting time and a study of clot retraction, may be very revealing in late hemorrhage cases.

*Capillary Fragility.* Increased capillary fragility has been reported in a wide variety of conditions. According to Rodriguez and Root<sup>11</sup> capillary permeability is increased in hypertensive states, diabetes and tuberculosis and may be improved by the administration of rutin, the flavone glucoside. Kushlan<sup>12</sup> has observed a striking improvement in the bleeding tendency of patients with hereditary hemorrhagic telangiectasia after rutin therapy. The tendency for the chronically hypertensive puerpera to experience late hemorrhage may be related to abnormal capillary permeability known to accompany hypertensive states. In the days before rutin therapy Strauss<sup>13</sup> reported a desperate case of repeated hemorrhages in the puerperium due to what he called constitutional capillary fragility. The vaginal mucosa in his

case required resuturing on five occasions and eventually the internal iliac arteries had to be ligated to control the persistent vaginal bleeding.

*Vitamin Deficiency.* Associated with abnormal bleeding tendencies is a deficiency of any one of four vitamins, namely, vitamin C, vitamin K, vitamin P (citrin) and vitamin B complex. In the scorbutic state there are large subcutaneous hemorrhages as well as bleeding from various body cavities. Vitamin P deficiency is manifest by universal capillary fragility which may be verified by the Göthlin petechial index. Inasmuch as vitamin K deficiency can allow bleeding from an extensive raw surface without bleeding from intact skin and mucosa, puerperal bleeding from the denuded uterine wall may be the only manifestation of vitamin K deficiency. The Biskinds<sup>14</sup> have written extensively upon the possible role of B complex deficiency, particularly thiamin and riboflavin, in the causation of menorrhagia. The theory is that the liver cannot conjugate and efficiently dispose of estrogens in the absence of adequate B vitamins, hence, the abnormal bleeding is thought to result from hyperestrinism. Therefore, it might be concluded that the obstetrical patient facing confinement with depleted vitamin stores is particularly liable to abnormal bleeding in the puerperium.

*Liver Disease.* The hemorrhagic tendency in jaundiced patients is due to the reduced blood level of prothrombin, which in turn is due to the decreased absorption of vitamin K, the antihemorrhagic vitamin. For the absorption of the latter it is necessary that bile be present in the intestine. In addition to the prothrombin deficiency women with liver disease probably develop hyperestrinism, as previously indicated. It will be recalled that the free hormone is considerably more potent than conjugated estrogen.

Recent studies<sup>15</sup> leave little doubt that acute yellow atrophy is an end stage of fulminant infectious hepatitis due to an icterogenic virus. Zondek and Bromberg<sup>16</sup>

encountered twenty-nine patients with infectious hepatitis among 3,382 pregnant women (0.85 per cent). Of the five fatal cases two women hemorrhaged shortly before death. I recall a patient who bled almost continuously for a week postpartum while in the preicteric phase of infectious hepatitis. Clinical jaundice did not appear until two days after curettage.

Although infectious hepatitis is the most frequent cause of icterus in pregnancy and the puerperium, it may result from hemolytic accidents (transfusion reactions) and from obstructive lesions of the biliary tract.

*Hypothyroidism.* The postpartum period seems to be one of the favorite phases in a woman's life for a previously normal or marginal thyroid to become hypoactive. One of the first manifestations of hypothyroidism may be menometrorrhagia. Thyroxine augments cellular activity throughout the body including, of course, the glands of internal secretion. According to the work of Van Horn<sup>17</sup> thyroxine tends to prevent the building up of excessive quantities of estrogenic hormone in the endometrium by promoting the elimination of estrogens through the urine. It is well known clinically that thyroid therapy is most effective in correcting instances of dysfunctional bleeding in hypothyroid women.

*Heparin and Dicoumarin.* A priori one would justifiably be wary of the use of anticoagulants such as heparin and dicoumarin in the prophylaxis and treatment of phlebothrombosis and thrombophlebitis because of the not improbable hazard of secondary postpartum hemorrhage. A more extended clinical experience with these anticoagulants will be necessary before the final answer is forthcoming.

#### HEMORRHAGE DUE TO GYNECIC DISORDERS

By far the great majority of instances of late postpartum hemorrhage arises in connection with a specific gynecic condition most commonly from a pathologic state of the uterine body but occasionally from a lesion in the vulvovaginal tract, the uterine

cervix or the adnexa. It may be of interest, therefore, to review the gamut of pathologic conditions arising within the reproductive system which may be associated with late puerperal bleeding.

#### *The Vulvovaginal Tract*

Ulcerative lesions of the vaginal tract, vaginal metastases from choriocarcinoma and rupture of a vaginal varix may cause bleeding late in the puerperium but perhaps the most frequent causes of delayed bleeding from the vulvovaginal tract are as follows:

*Vulvovaginal Hematoma.* This may follow spontaneous as well as operative vaginal delivery and it is often quite insidious in onset. According to Duckman and Tortora<sup>18</sup> only 187 cases have been reported since the first recorded instance in 1554; however, the condition is doubtless much more common than the number of reported cases would indicate. A paravaginal hematoma may arise in association with episiotomy or without incision of the perineum. Perineal pain, arising a day or two postpartum and which is unusually severe and makes little or no response to opiates, should suggest the possibility of a developing vulvovaginal hematoma. One recent case, attended by myself, manifested itself on the tenth postpartum day following delivery by outlet forceps and medio-lateral episiotomy on the side opposite to which the hematoma developed. Approximately 500 cc. of liquid and clotted blood escaped from the hematoma several days after the patient's return home from the hospital. Readmission was necessary for tamponade and administration of blood transfusion. It was believed that the hematoma formed as a result of the spontaneous rupture of a vulvar varicosity of which the patient, although a primipara, had many. Large hematomas, which do not resorb or which are not spontaneously or surgically drained, have been known to dissect along the loose cellular tissues to eventuate in a broad ligament or retroperitoneal hematoma. Although perineal

pain may suggest the possibility of a hematoma developing, it may be a week or more before the tumorous collection of blood is evident. With the present tendency for brief hospital stay postpartum, the attendant may not become aware of a vulvovaginal hematoma until spontaneous rupture or secondary infection of the lesion has occurred. With hematomas which develop in connection with episiotomy, however, the tumor is usually obvious within twelve to twenty-four hours postpartum.

*Rupture of the Vaginal Vault during Coitus.* Although a rare accident, according to Diddle,<sup>19</sup> 133 major tears of the vaginal vault resulting from coitus have been recorded in the past 76 years. This figure includes the two recent cases encountered by Diddle. Of the 133 cases, 22 patients died giving a mortality of 16.7 per cent for the accident. The usual symptoms are vaginal pain during coition with bleeding thereafter. Diddle's first patient was admitted because of moderately severe vaginal bleeding coming on after first coition following delivery two months previously. Examination disclosed a crescentic tear 4 cm. long involving the entire thickness of the vaginal wall. His second case occurred in a colored primipara who returned to the hospital sixteen days after normal parturition. The patient admitted having had coitus three days before return to the hospital. Examination disclosed a gaping tear in the left posterior vaginal fornix. Treatment consisted of blood transfusion, rest and hot vaginal douches. Healing was nearly complete within a week.

Although rupture of the vaginal vault during coitus is an exceedingly rare lesion in private obstetrical practice, it is sometimes encountered in clinic patients. The importance of a full history and careful speculum examination should not be overlooked.

*Vaginal Wall Lacerations.* Secondary infection in a repaired vaginal wall laceration may evoke premature digestion of the suture material with sudden brisk bleeding

in the early puerperium. Even with careful hemostasis a hematoma may form under the suture line of a vaginal laceration, become infected and rupture usually five to eight days postpartum.

*Vaginal Cuff Following Complete Hysterectomy.* Several years ago at the Maternity Hospital of Cleveland I had the opportunity of attending a patient who had undergone total hysterectomy several hours postpartum because of rupture of a myomatous uterus which followed breech extraction. Sudden massive, almost exsanguinating postoperative hemorrhage occurred about three weeks postpartum and was found to be due to the erosion of an angular artery in the vaginal cuff. The patient recovered following transfixion of the bleeding artery, vaginal tamponade and generous blood replacement.

Cesarean section followed by immediate total hysterectomy and total hysterectomy done soon postpartum (for severe atony or rupture) are uncommonly performed operations. Also, the circumstances under which they are done are typically characterized by expediency and haste; hence the usual precautions in transfixing the vaginal cuff vessels may not be observed and, moreover, the increased vascularity of the parts in the pregnant state renders good hemostasis difficult to accomplish. The risk of serious late bleeding in these cases is a real hazard, particularly inasmuch as it may not happen until several days after the patient has returned home as occurred in the case previously cited.

### *The Uterine Cervix*

Although the uterine cervix itself is a rare source of secondary puerperal hemorrhage, there are several pathologic entities which should be considered in the differential diagnosis of delayed bleeding.

*Lacerations.* Repaired lacerations of the uterine cervix may give rise to late bleeding in one of several ways: Infection along the suture line may cause premature digestion of the catgut with late hemorrhage on about the seventh day. The descending



cervical branch of the uterine artery may hemorrhage in the early puerperium if the primary suturing of the upper extremity of the laceration was not carefully performed; proper closure of the upper angle of extensive cervical tears is the most essential step in the primary repair as far as permanent hemostasis is concerned. When one considers how the azygos vaginal artery anastomoses with the descending cervical rami of the uterine arteries to form an arterial circle, called the coronary artery of the cervix, it is remarkable that there are not more instances of secondary hemorrhage from aneurysm formation in connection with lacerations which involve major arterial channels. What has been said previously regarding lacerations of the cervix applies equally as much to trachelotomy or Dührssen's incisions of the uterine cervix. Extensive cervical lacerations which are not immediately recognized and repaired are properly considered under primary postpartum hemorrhage as the bleeding continues postpartum until repair is made or the patient exsanguinates herself.

*Carcinoma.* A hitherto unrecognized cervical carcinoma may ulcerate and bleed in the puerperium and elicit secondary hemorrhage. I can recall such an occurrence in an unregistered patient who first hemorrhaged on the seventh postpartum day. In a recent study of the postpartum cervix Sheets<sup>20</sup> encountered two cases of clinically unsuspected, grossly not discernible, invasive carcinoma of the cervix in an unselected series of 200 postpartum cervixes. From a histologic study of 1,200 specimens removed in the course of panhysterectomy Pund and Auerbach<sup>21</sup> diagnosed unsuspected carcinoma in 3.9 per cent of the cervixes. Hence the figures usually cited for the incidence of carcinoma of the cervix coincident with pregnancy (one case in 2,000 to 3,000 deliveries) may have to be revised. A contemplation of these two studies previously cited would behoove the attendant to consider the possibility of cervical carcinoma in the differential diagnosis

of secondary puerperal hemorrhage particularly in the older multiparous parturient.

*Cervical Stump Following Supravaginal Hysterectomy.* Even after cesarean-supravaginal hysterectomy there is a risk of late hemorrhage. In his series of 168 cases of cesarean-hysterectomy Dieckmann<sup>22</sup> encountered among the postoperative complications two instances of hemorrhage from the cervical stump on the tenth postpartum day. Both cases were managed by the application of clamps to the cervix for forty-eight hours; neither patient required a blood transfusion. With the wider vogue which cesarean-hysterectomy is currently enjoying, one may encounter more instances of secondary hemorrhage from the remaining stump.

*Miscellany.* Cervical erosion, cervical polypi and papillary cervicitis may cause bleeding in the puerperium. Although cervical varicosities are rare and although they usually bleed during pregnancy if they are going to bleed, they should be remembered as possible sources of delayed bleeding in the puerperium. The importance of thorough visualization of the cervix and vaginal tract in instances of late bleeding cannot be overemphasized.

### *The Corpus Uteri*

The overwhelming majority of instances of secondary puerperal hemorrhage arises from pathologic conditions of the uterine body. A wide range of disease entities is represented in a scrutiny of the pathogenesis of late postpartum hemorrhage from this source. The various pathologic entities will be reviewed in the order of their clinical frequency. However, before proceeding with the specific entities it might be appropriate to review briefly the physiology and management of the third stage of labor which is exceedingly important in the prevention of both primary and secondary postpartum hemorrhage.

The proper conduct of the third stage of labor demands first that the baby be delivered slowly; Dieckmann<sup>23</sup> recommends that three minutes be so spent. This is to

give the uterus time to contract slowly about the placenta and thus detach it by a squeezing process. The retroplacental hematoma has little or nothing to do with separation of the placenta if the delivery of the child is conducted slowly and if the third stage of labor is properly managed. The Schultze and Duncan types of placental presentation have nothing to do with the process of placental separation and depend merely upon whether or not the detached placenta encounters a tight ring such as a contracted lower uterine segment or vaginal orifice on the way out of the birth canal.

No attempt should be made to deliver the placenta until the uterus has regained its globular form when the fundus should be gently compressed provided the uterus is definitely firm and not atonic. The fundus should never be pushed into the axis of the pelvis for risk of inversion. If the placenta lies free in the vagina, it should be delivered by gentle traction on the cord. The administration of post-pituitary extract after the second stage promotes contraction and retraction of the uterus and placental separation. Relaxation of the fundus with bleeding in the third stage calls for stimulation by massage, bimanual compression and repetition of an oxytocic agent. Should these measures fail, the placenta should be extracted manually. If uterine bleeding continues after the placenta has been delivered intact, the uterine cavity should be manually explored to exclude a retained succenturiate lobe, retained blighted ovum of a multiple pregnancy,<sup>24</sup> myoma, rupture and inversion. The observation that the placenta presents a punched-out defect on its maternal aspect should suggest the presence of a submucous myoma. I believe that in modern obstetric practice there is still an occasional call for the timely use and proper application of a uterine pack particularly in instances of severe atony. Such tampons, if employed, should rarely be allowed to remain *in situ* for more than eight hours. Once in a great while primary



FIG. 1. Retained placental tissue removed by curettage on nineteenth postpartum day; nubbin of tissue was missed on curettage done on twelfth postpartum day when only evidence of chronic endometritis was found on microscopic examination.

atony may even demand the timely use of hysterectomy. *Pari passu* with the local measures mentioned, blood replacement therapy must be prompt and adequate.

**Retained Placental Tissue.** The most frequent cause of late postpartum hemorrhage is retention of placental tissue. The amount of placenta retained may vary from a small nubbin (Fig. 1) or lobule to an entire accessory lobe. Even the most careful scrutiny of the delivered placenta may fail to disclose the missing fragment of a cotyledon which later may become the source of serious delayed bleeding. With retained placental tissue there is typically no let-up of the lochia rubra, and brisk hemorrhage occurs when, during the process of involution, the uterus contracts around the retained tissue partially detaching it from the uterine wall. Partially detached tissue can hold open a blood vessel and interfere with retraction so that the vessel continues to bleed; not until the tissue is removed will the vessel retract and the bleeding cease. A fragment of placental tissue may gradually become organized and incorporated as an integral part of the uterine wall; such a placental polyp may be recovered weeks, months or even years later on curettage or hysterectomy for abnormal uterine bleeding. Dorsey<sup>25</sup> reports an instance of sudden

profuse hemorrhage (1,500 cc.) on the twenty-second postpartum day from a small placental polyp. Hagstrom<sup>26</sup> records an interesting instance of desperate late hemorrhage occurring in a primipara on the eighteenth postpartum day. Curettage provoked such brisk hemorrhage that hysterectomy had to be carried out as a life-saving procedure. The pathologic finding was a simple placental polyp. It should be emphasized that despite all due vigilance and care in the conduct of the third stage of labor and keen scrutiny of the afterbirth, occasional instances of retention of bits of placental tissue do occur. Almost always in such cases review of the original delivery record will describe the placenta as having been delivered whole and intact.

*Succenturiate Lobe.* According to Waters<sup>27</sup> succenturiate lobe occurs about once in 500 deliveries. Retention of such an accessory lobe may be a most treacherous source of delayed hemorrhage. When the placenta has been described as intact at the time of delivery but a copious amount of placental tissue is obtained on curettage performed a week or so later for secondary hemorrhage, a very substantial number of such instances is doubtless due to a missed succenturiate lobe. It is important to check the delivered placenta for gaping, sizeable marginal vessels which would indicate vascular connection with a retained succenturiate lobe. On the other hand, it rarely happens that the small accessory lobe is delivered first. If the placenta is inordinately small for the size of the fetus, it behooves the attendant to explore the uterine cavity forthwith for the main placenta. I once observed placenta previa to be due to a succenturiate lobe and Waters<sup>27</sup> reports a case of placenta previa due to a succenturiate lobe 10 cm. in diameter. What has been said concerning succenturiate lobe applies equally as much to the retention of half of a duplex placenta. Just recently I encountered at cesarean section the retained half of a duplex placenta, the first half having come away spontaneously and quite intact.

If a cotyledon of placenta, a succenturiate lobe or half of a duplex placenta is retained, the lochia rubra persists beyond the seventh day, there are bouts of brisk bleeding, the uterus remains boggy and subinvolved and often there is a low-grade fever. According to Wolfe and Pedowitz<sup>28</sup> the cervix is normally patulous until the twelfth postpartum day; however, finding the cervix patulous after that time is highly suggestive of retained placental tissue. Bleeding will continue as long as the partially detached placental tissue keeps the underlying blood vessels open and unable to retract. The indication for prompt curettage as soon as the diagnosis is reasonably established is obvious.

*Placenta Previa Accreta.* Chisholm<sup>29</sup> recently reported a most interesting case of placenta previa accreta occurring in a thirty-five year old secundipara. The patient's first puerperium was complicated by secondary postpartum hemorrhage six weeks after delivery for which curettage was carried out. The second pregnancy was complicated by placenta previa for which cesarean section was carried out in the thirty-fourth week. At operation an accreta placenta previa was encountered and "all that safely could be done was to remove as much as possible of the placenta piecemeal." Late postpartum bleeding began on the sixteenth day and a firm pack was inserted into the cervical canal on the seventeenth day. By the nineteenth day of the puerperium the patient's condition had sufficiently improved so that total abdominal hysterectomy could be undertaken. The patient gradually improved and was discharged from the hospital on the fifty-sixth day. Microscopic examination of the uterus showed a total absence of the decidua basalis as well as a poorly defined Nita-buch's membrane so that the villi lay mostly on the muscular layer.

*Retained blood clots or membranes* alone are rarely the cause of late postpartum hemorrhage although occasionally careful evacuation of the puerperal uterus may fail to yield anything else. In such instances,



FIG. 2. Section through decidua basalis, cesarean-hysterectomy specimen, showing minimal spongy layer remaining and absence of distended blood vessels; the numerous fetal giant cells are diagnostic of the placental site. By forty-five minutes postpartum the blood vessels of the placental site become distended and partially thrombosed.

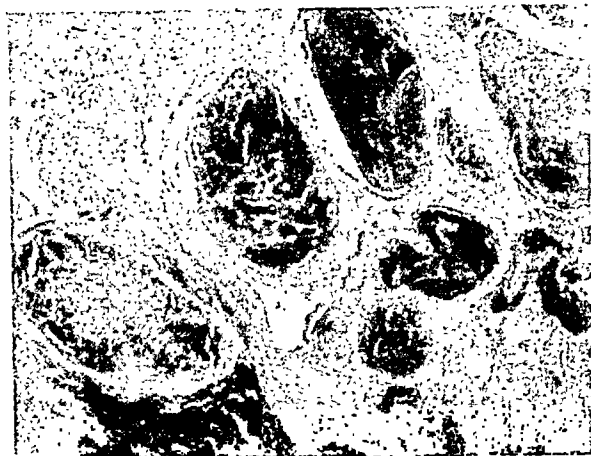


FIG. 3. Section taken through normal placental site thirty-two hours postpartum (cesarean section); patient expired from ruptured congenital aneurysm of circle of Willis one month from term. Section shows remarkable thrombotic obliteration of placental site veins.

one always wonders if perhaps a nubbin of placental tissue were not "missed" or some other pathologic entity not detected.

*Persistent Placental Site.* The anatomic changes which occur in the uterine mucosa postpartum or postabortum are indeed fascinating. A cleavage plane appears in the decidua vera by the second or third day postpartum, dividing the spongy layer into an inner necrotic zone and an outer, well-preserved lamella which adjoins the muscularis. The inner necrotic zone is separated by a process of ischemic necrosis due to vasospasm of the spiral arterioles; the process is indeed like menstruation. The desquamated layer is cast off in the lochia whereas the preserved inner lamella contains the fundi of the glands and constitutes the matrix whence the new endometrium is regenerated. Approximately seven to ten days are required for the new endometrium to cover completely the area previously occupied by the decidua vera.

The fate of the placental site, however, is a totally different process. In his last paper Williams<sup>30</sup> presented a scholarly exposition of the changes which take place in the placental site; similarly, Teacher<sup>31</sup> devoted much study to the healing of the placental site. It has been established that the placental site blood vessels, both arteries and veins, start their process of obliteration

during the second stage of labor and continue it during and after completion of the third stage. (Fig. 2.) Vascular obliteration is accomplished by venous sinus thrombosis and obliterating endarteritis. (Fig. 3.) The placental site is not absorbed *in situ* but rather heals by a process of exfoliation in which the placental site is virtually "lifted off" by the growth of a new epithelium from the periphery as well as by the sprouting of regenerated mucosa from the gland stubs underlying the placental site. Williams<sup>32</sup> found an exfoliation of tissue from the placental site during the entire first six weeks postpartum; hence, about six weeks are usually required for disappearance of the placental site although with the unaided eye it is most difficult to detect the placental site by ten to fourteen days postpartum according to Rutherford.<sup>33</sup>

Occasionally there is delay in extrusion of the placental site. According to Rutherford<sup>33</sup> placental sites have been reported as late as nine weeks postpartum. Williams<sup>30</sup> maintained that both intra-uterine infection and the retention of fetal tissue definitely delayed involution of the placental site. The clinical picture of subinvolution of the placental site is practically identical with that of retained placental



FIG. 4. Persistent placental site; specimen obtained in late puerperium from secondary postpartum hemorrhage case. Note patency of blood vessels. (Specimen courtesy of Herbert F. Traut, M.D.)

tissue: (1) lochia rubra persisting beyond the seventh day or bouts of frank uterine bleeding; (2) subinvolution of the uterus as a whole and (3) usually, low-grade pyrexia of 99 to 100°F. Faulty involution of the placental site is really a rather frequent cause of late bleeding following either abortion or term delivery. Erviny and Power<sup>34</sup> regarded it as quite common for in their series of 134 postpartum evacuations for late bleeding they recovered actual placental tissue in only ten instances. Rutherford and Hertig<sup>35</sup> made a careful study of three cases of serious secondary puerperal hemorrhage proved to be due to non-involution of the placental site. The characteristic finding on pathologic examination of the tissue removed was patent or incompletely obliterated blood vessels. (Fig. 4.) All three patients were curetted but the third one required hysterectomy eight days after curettage because of continued bleeding. These authors believe that the condition is more likely to occur in multiparas and that there is a tendency for it to recur in subsequent pregnancies. The mechanism of bleeding is obviously the result of hemorrhage from the placental site blood vessels which remain patent, or at least incompletely obliterated, at the time the placental site is in the process of being extruded. Dieckmann<sup>23</sup> encountered persistent placental site as the most frequent finding in the

patients readmitted for curettage for late puerperal bleeding; only rarely was placental tissue obtained in his patients at Chicago Lying-In Hospital.

In conclusion it might be stated that persistence or non-involution of the placental site is a common cause of secondary postpartum hemorrhage. The reason for failure of proper vascular obliteration is not known. The bleeding may be so profuse or so prolonged that even hysterectomy may be mandatory. This phenomenon may follow abortion as well as term delivery. McSweeney<sup>36</sup> encountered it as the cause of death in one patient who expired on her twenty-third day following delivery by cesarean section.

*Blighted Secondary Ovum.* Leff<sup>24</sup> calls attention to the possibility of retention of a blighted secondary ovum of a multiple pregnancy as a hitherto overlooked cause of secondary postpartum hemorrhage. Leff believes that when there is an interlude of a number of days of normal lochia before actual bleeding begins, one can be quite sure he is not dealing with retained secundines. In one of Leff's cases curettage for late bleeding yielded a cast of an embryo which measured 5 by 3 cm. The smaller the retained ovum the longer it will be before the uterus involutes to a small enough size to encroach upon the retained ovum and cause its detachment. Bleeding results from partial separation of the retained tissue, with hemorrhage from the torn vessels which cannot retract as long as the tissue remains attached. Some of Leff's cases occurred as late as thirty days postpartum.

If the placenta as originally delivered is described as whole and intact and if one is sure there was no succenturiate lobe involved, the finding of placental tissue on curettage for late bleeding suggests, according to Leff, that one is dealing with the residue of a blighted secondary ovum of what started out as a multiple pregnancy.

*Decidual Separation.* In his classical paper Williams<sup>37</sup> pointed out that no hard and fast rules can be laid down as to just

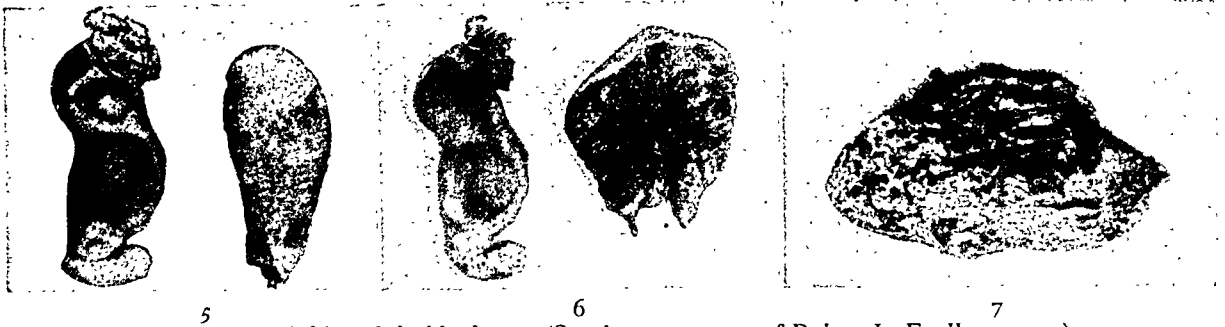


FIG. 5. Tubal pregnancy (left) and decidual cast. (Specimen courtesy of Robert L. Faulkner, M.D.)

FIG. 6. Tubal pregnancy (left) and decidual cast bisected. (Courtesy of Robert L. Faulkner, M.D.)

FIG. 7. Decidual cast from case of tubal pregnancy; note extensive hemorrhage throughout cast. (Courtesy of Robert L. Faulkner, M.D.)

how much decidua will be retained either in the placental site or elsewhere in the postpartum uterus. He found, in actual fact, that the amount of decidua retained varied considerably in different specimens; there were all graduations from a thick layer on the one extreme to "minute decidual triangles between the serrated margins of the muscularis on the other." In 1926 Frankl<sup>2</sup> published an interesting study of late postpartum hemorrhage due to hyalinized vascularized decidual rests or islands. Of a series of 460 patients who first bled at least a week postpartum or postabortion, the author collected six hysterectomy specimens from patients who presented no other organic pelvic disease and who showed no histologic evidence of retained chorionic tissue. The only pathologic finding in this carefully selected series of cases was vascularized decidual rests. To the latter Küster<sup>38</sup> is credited with having given the name deciduoma. Frankl<sup>2</sup> hypothesized that the retained islands of decidua became unduly vascularized by what he called the plexus venosus varicosus endometrii. On gross scrutiny of the excised uteri the islands of vascularized decidua could not be differentiated from nubbins or plaques of retained placenta. In his textbook Williams<sup>39</sup> mentions how he himself had been "surprised to find that a portion of decidua only a few millimeters in diameter may lead to serious consequences" as far as puerperal bleeding is concerned.

Palik and Rechnitz<sup>40</sup> recently reported a series of nine cases of hemorrhage late in December, 1949

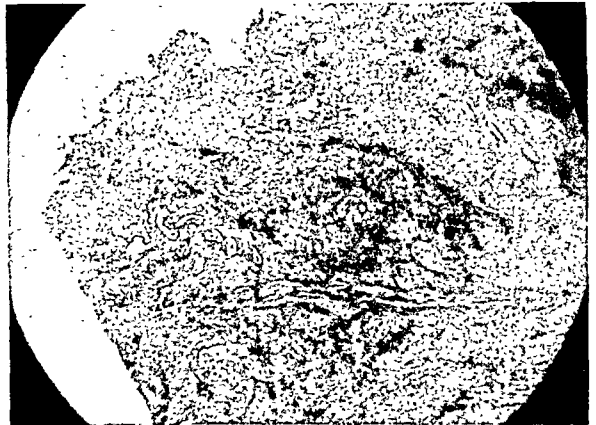


FIG. 8. Decidual cast; the hemangiomatous character of the normal cast is striking. When separation occurs, the bleeding may be profuse and alarming.  $\times 20$ .

the puerperium, five after abortion and four after full-term delivery. In each instance the only cause of bleeding that could be ascertained on study of the curettings was hyaline degeneration of decidual rests.

In addition to the pathologic entity of hyalinized vascularized decidua previously described serious late bleeding may arise from the separation of really quite normal decidua. I have encountered this complication a week or more after salpingectomy for tubal pregnancy (Figs. 5, 6, and 7). Richly vascularized decidua (Fig. 8) was the only finding on pathologic examination of the uterine curettings. Were it not for the frequency with which curettage is done as a diagnostic procedure before laparotomy in so many cases of ectopic pregnancy, this complication of late bleeding would no doubt be more commonly en-

countered. The writer can recall an instance of late postpartum bleeding which arose from the non-pregnant horn of a double uterus in a patient who had been delivered over a week previously by cesarean section.

*Subinvolution.* Involution is the process whereby the recently pregnant uterus gradually returns to its natural nongravid state. During the involutional period, which we prefer to regard as lasting three months, the uterus shrinks from a weight of 2 pounds to a definitive weight of 1 to 2 ounces. The process of involution involves autolytic changes which lead to atrophy of individual muscle cells; the alleged mechanism of fatty degeneration which used to be held in no longer tenable.

Subinvolution is that condition in which there is a delay or arrest in the process of return to the normal non-pregnant state. However, this is not a primary disease *sui generis*. Instead, it is typically secondary to some other pathologic state. Conditions which may impede involution include: (1) retention of placental tissue; (2) imperfect exfoliation of decidua; (3) faulty involution of the placental site; (4) the presence of myomatous or adenomyomatous nodules in the uterine wall and (5) pelvic vascular engorgement which may result from uterine or adnexal inflammation or from uterine retrodisplacement.

The symptoms of subinvolution include persistent lochia rubra or frank bleeding, a sensation of pelvic heaviness and usually low backache. The diagnosis is established by bimanual examination. The uterus is found to be soft and boggy and larger than one would expect for the length of time which has elapsed since delivery and often there is an associated retrodisplacement.

The process of involution is never really complete as it is always possible to distinguish a parous from a nulliparous uterus by the demonstration of more or less elastic tissue around the blood vessels. If the perivascular elastic tissue were absorbed during the puerperium, *pari passu* with the muscular tissue, involution would really be complete; however, this is never

the case and parity can always be established by histologic demonstration of perivascular collars of elastic tissue. Should the state of arrested involution become static, a type of chronic metritis known as chronic subinvolution obtains and is histologically characterized by the demonstration of excessive amounts of elastic tissue around the myometrial blood vessels. This entity has been very well described by William Fletcher Shaw<sup>41</sup> and by Otto Schwarz.<sup>42</sup> Clinically, it is manifested by a symmetrically enlarged uterus which is smooth in contour and by a history of prolonged and excessive menses dating from an antecedent pregnancy. The active treatment of subacute subinvolution cannot be overemphasized if chronic subinvolution is to be avoided. However, the pathogenesis of chronic subinvolution is indeed obscure in not a few instances and the likelihood of an endocrinopathic origin seems quite probable.

*Dysfunctional Uterine Bleeding.* This term implies that an aberration of physiologic mechanism rather than the existence of an organic disease is the pathogenic factor. The puerperium is all too often the setting in which dysfunctional bleeding begins. This is not surprising when one realizes the implications of the dynamics involved in the readjustment of the endocrine system following parturition or abortion.

Dysfunctional uterine bleeding can arise from any type of endometrium and usually it is anovulatory. Most functional excesses derive from an interval or estrogenic endometrium. The latter may be poorly proliferated (atrophic), normally proliferated or excessively proliferated (hyperplastic). The frequency with which cystic glandular hyperplasia of the endometrium is encountered in instances of dysfunctional bleeding arising in the late puerperium probably reflects a hangover of the anterior pituitary hyperfunction characteristic of gestation. Endometrial hyperplasia, like acromegaly, is most frequently encountered during periods of pituitary overactivity,

that is, during puberty, the climacteric and in the puerperium. Just as mild acromegaloid changes characteristic of pregnancy usually regress postpartum, although an occasional instance passes over into genuine acromegaly, similarly, postpartum hyperplasia may persist in a chronic recalcitrant state. According to Markee and Berg<sup>43</sup> antecedent drops of approximately 50 per cent in estrogen levels usually are associated with physiologic uterine bleeding. Moreover, there is usually a time lag of two to five days in the estrogen-bleeding relationship. Critical drops in blood estrogen content produce transient vasospasm of the spiral arterioles, with resulting ischemic necrosis of the endometrium and eventual bleeding.

Even though most cases of dysfunctional uterine bleeding observed in the late puerperium are anovulatory in origin and associated with an estrogenic endometrium, there is a distinct and not inconsiderable group associated with ovulation. In a classical paper published in 1935 Traut and Kuder<sup>44</sup> described "irregular shedding and irregular ripening of the endometrium" which is characterized clinically by cyclic menorrhagia, with bleeding for ten to fourteen days each month. With normal menstruation practically all the endometrium in the secretory phase is sloughed off in forty-eight hours; by seventy-two hours none is left. With irregular shedding of the endometrium, however, curettage done on the fifth or sixth day of the bleeding episode discloses secretory-phase endometrium. The glands are usually stellate in outline and the blood vessels are old (endarteritis obliterans). To establish the diagnosis curettage should be done on the fifth or sixth day of the bleeding episode. Holmstrom and McLennan<sup>45</sup> recently made a detailed report of three cases of irregular shedding of the endometrium: All three patients had had normal menses prior to pregnancy following which regularly recurring menorrhagia developed. Curettage was without avail in any case. The authors recommend, when necessary, hysterectomy

in younger subjects and radium in older patients.

*Diethylstilbestrol.* More and more instances of serious secondary bleeding have been encountered in women who have received diethylstilbestrol either to inhibit lactation or to "dry up" the breasts after the establishment of lactation. Typically there is a lag of several days to a week or more between the last dose of the hormone and the onset of uterine bleeding. The bleeding may be profuse and exsanguinating. It is due to hyperestrinism and curettings typically show a pronounced estrogenic endometrium without other pathologic findings. Bimanual examination discloses no evidence of subinvolution or other abnormal findings in the uncomplicated case of hyperestrinism.

The writer has often observed considerable delay in the reestablishment of ovulation and normal cyclic bleeding after stilbestrol administration in the puerperium. Whether or not an episode of serious late bleeding occurs, as previously described, often there will be a prolonged period of amenorrhea lasting for several months and not infrequently followed by a phase of metrorrhagia. It seems not unlikely that, in certain cases at least, the exhibition of stilbestrol in the puerperium can so depress the anterior lobe of the hypophysis that gonadotropin secretion is held in abeyance for an indeterminate period. From my personal experience with the use of stilbestrol in the puerperium for its alleged inhibitory effect upon lactation, I have concluded that its frequent disadvantages far outweigh its possible benefit. The all too frequent disadvantages are as follows: (1) Lactation in many cases is simply delayed and not really prevented hence, it often appears shortly after the patient's return home where the facilities for its symptomatic relief are not nearly so accessible as in the hospital; (2) the risk of secondary hemorrhage is frequent and often serious enough to require curettage and (3) prolonged amenorrhea, punctuated with episodes of profuse or extended



metrorrhagia and undue delay in the reestablishment of ovulation and normal cyclic bleeding, often occurs.

*Uterine Hypotonia.* Just as profuse hemorrhage may occur immediately postpartum from uterine atony, so may various degrees of uterine hypotonia in the puerperium be associated with prolonged or profuse excesses of uterine bleeding. The control of bleeding in the postpartum uterus depends upon several factors: (1) the "living ligature" action of uterine musculature in retraction and contraction; (2) venous thrombosis and (3) obliterative endarteritis. The fate of the blood vessels in the placental site has been taken up earlier in this paper.

A variety of morbid conditions may bring about diminished tone in the puerperal uterus with resulting prolonged or profuse bleeding. Patients who suffer immediate postpartum hemorrhage from uterine atony due to overdilatation of the viscus from hydramnios or plural pregnancy or from uterine fatigue due to prolonged labor may require several days before regaining normal uterine tone, during which time persistent or recurrent bleeding may occur. More frequent, however, than the aforementioned instances of primary hypotonia due to muscular paralysis or fatigue are the occurrences of puerperal atony secondary to some mechanical factor which causes myometrial insufficiency. Retained placenta, myomas and adenomyosis are abnormalities which can interfere with uterine contraction and retraction. In rare cases the presence of adhesion between the uterus and surrounding organs or parietal peritoneum may prevent proper muscular contraction. According to Williams<sup>46</sup> atony may be associated with degeneration of the muscle fibers from an abnormal invasion of fetal elements.

The soft, hypotonic postpartum uterus may be a serious threat to the patient's life and health. Persistent oozing may go on for days or there may be a sudden profuse hemorrhage. The various factors to which

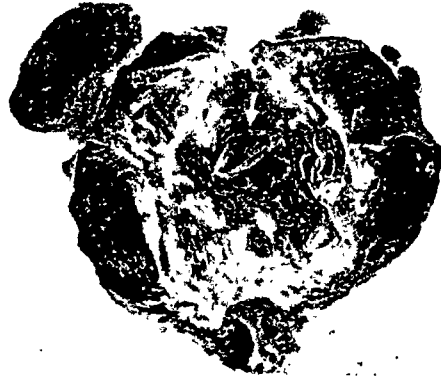
hypotonia may be secondary should be carefully considered before it is assumed that the atony is primary. In either event the seriousness of the bleeding and its failure to respond to oxytocics may require timely surgical intervention including exploration of the uterine cavity, curettage, tamponade and, rarely, even hysterectomy.

*Neoplasms.* A variety of uterine neoplasms must be considered when inquiring into the causation of secondary postpartum hemorrhage from this source. The tumors which have been encountered as responsible for late hemorrhage include myomas, adenomyosis, endometrial polypi, chorio-carcinoma, endometrial sarcoma, endometrial carcinoma and hemangioma of the uterine wall.

*Myomas* may cause late bleeding depending upon the location of the tumor and its pathologic stage. Subserous tumors may be excluded as a possible source of late hemorrhage. Intramural myomas may produce repeated bouts of late bleeding due to their mechanical interference with myometrial contraction and retraction, as described under uterine hypotonia. The classical cause of late bleeding from myomas appertains to submucous tumors. The latter may evoke bleeding by a variety of mechanisms: They may interfere with endometrial healing and regeneration. Pedunculated submucous myomas may bleed because of necrosis of the covering epithelium. The point of bleeding in the ordinary uterus with a submucous myoma is frequently not over the myoma itself but from the thick endometrium in some nearby furrow. Localized hypertrophic endometrium bleeds when its elongated fronds have outgrown their blood supply, with subsequent necrosis. Submucous myomas which have undergone red degeneration are particularly likely to be associated with secondary bleeding because of the tendency of red myomas to cause placenta and membranes to become glued to them. (Figs. 9 and 10.) According to Faulkner<sup>47</sup> red myomas, by and large, are the only ones with enough peripheral reaction to cause placenta (or



9



10

FIG. 9. Complete uterus bisected to show large submucous myoma which has undergone red degeneration; specimen removed seventy days postpartum. Retained placenta when manually extracted after ninety-minute third stage was found adherent to submucous myoma. Curettage for delayed puerperal hemorrhage on forty-fourth postpartum day showed chronic endometritis. (See Fig. 11.)

FIG. 10. Cesarean-hysterectomy specimen removed for multiple fibromyomas; note how the membranes are adherent to a myoma showing resolving red degeneration. Red myomas are the only ones with enough peripheral reaction to cause placenta or membranes to remain adherent. (Courtesy of Robert L. Faulkner, M.D.)

bowel) to stick to them; hence the source of late bleeding in such instances may be retained placental tissue adherent to a red submucous myoma. The very rare sarcomatous degeneration of myomas may, of course, lead to delayed bleeding.

What has been said about the mechanism of delayed bleeding from the uterus with interstitial myomas applies to the dynamics in cases of internal endometriosis or *adenomyosis*. Szenes<sup>48</sup> has presented a classical monograph on adenomyosis as a cause of severe hemorrhage in the third stage of labor and in the puerperium.

Profuse hemorrhage may occur from *endometrial polypi* which typically have a sizeable central artery which bleeds freely when the mucosal covering is eroded. Such tumors, especially if situated in a cornu, are all too easily missed with a curette. The ordinary slightly curved uterine dressing forceps is a most useful instrument to employ after curettage for prehending an elusive polyp.

*Choriocarcinoma* is a malignant tumor of chorionic epithelium which may follow abortion, delivery at full-term or hydatidiform mole. It occurs about once in 30,000 deliveries. Of the seventy hyda-



FIG. 11. Photomicrograph of choriocarcinoma showing blood vessel almost entirely lined with tumor cells; the mechanism of bleeding is the erosion and invasion of blood vessels by neoplastic tissue.  $\times 40$ . (Courtesy of Howard T. Karsner, M.D.)

tidiform moles investigated by Brews,<sup>49</sup> only 8.3 per cent eventuated in choriocarcinoma. Repeated bouts of uterine hemorrhage or continual uterine bleeding is the chief symptom. The mechanism of bleeding is the erosion and invasion of uterine blood vessels by advancing sheets of tumor cells. (Fig. 11.) One must be wary in curetting uteri suspected of harboring choriocarcinoma as profuse and even fatal hemorrhage has been known to ensue.

A most extraordinary situation is the



FIG. 12. Hemangioma of posterior uterine wall; patient had repeated spontaneous incomplete abortions with prolonged and excessive bleeding after each curettage. Note the great thickness of the posterior uterine wall due to the extensive hemangioma. (Courtesy of Herbert F. Traut, M.D.)

coexistence of pregnancy and *endometrial sarcoma*. In 1948 Eastman<sup>50</sup> abstracted a case published by Stutzer<sup>51</sup> in the German literature. The patient experienced recurrent hemorrhages six weeks after surgical completion of an early incomplete abortion. Examination disclosed what was taken to be a myomatous uterus and hysterectomy was carried out. Scrutiny of the opened specimen showed a grossly malignant tumor, the cavity being filled with polypoid tumor masses. Microscopic study established the diagnosis of endometrial sarcoma. The patient expired six months after hysterectomy, despite postoperative roentgen therapy. Eastman refers to the two other reported cases of pregnancy associated with endometrial sarcoma. Both manifested themselves at 15 days and five weeks postpartum, respectively, by fever and uterine enlargement.

*Carcinoma* is surely a rare cause of late puerperal hemorrhage inasmuch as a carcinomatous endometrium is poor soil for the nidation and development of a preg-

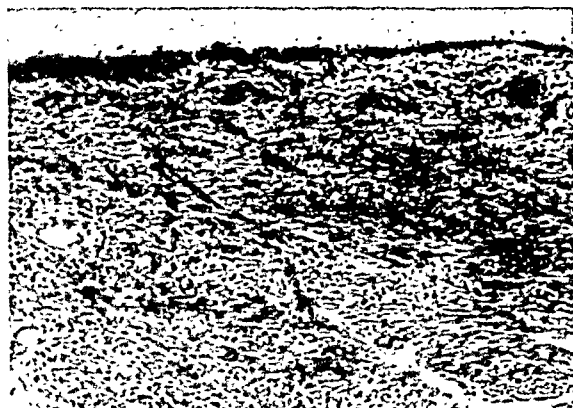


FIG. 13. Photomicrograph of curettings obtained from specimen shown in Figure 9 when patient had a severe hemorrhage on the forty-fourth postpartum day. Section shows typical chronic endometritis. The plasma cell infiltration is quite conspicuous.

nancy. However, I recall an instance of secondary hemorrhage occurring almost two weeks after salpingectomy for tubal pregnancy; investigation revealed a fairly advanced fundal carcinoma.

An excessively rare tumor is *hemangioma of the uterine wall*. Such a case was recently encountered by Dr. Herbert F. Traut.<sup>52</sup> The patient experienced repeated spontaneous abortions, all of which were followed by prolonged excessive bleeding despite curettage and transfusions. At the time of exploratory hysterotomy a greatly thickened and soft posterior wall was encountered. The hysterectomy specimen showed the cause of the enlargement and of the repeated postabortal hemorrhages to be an extensive hemangioma. (Fig. 12.)

*Endometritis*. This is really a rather rare cause of late bleeding and it is doubtless a much overworked diagnosis. When it does occur, it is much more likely to follow abortion than term delivery and its principal symptom is continued bleeding. When it follows term delivery, it is usually associated with retained secundines, submucous myomas or antecedent intra-partum infection. (Fig. 13.) As noted previously, endometritis is one of the several causes of subinvolution. One may be quite certain that unless there is something retained or present in the uterine cavity to cause and perpetuate the endo-

metritis, with the exception of tuberculous endometritis, inflammation of the endometrium does not persist for any length of time. The finding of simple endometritis on curettage in a case of late bleeding suggests that some primary entity, such as retained placental tissue or submucous myomas, probably exists but was just not demonstrated.

When endometritis is associated with chronic bleeding, as it rarely is, the underlying fault is most likely chronic myometritis, with diffuse enlargement of the uterus. The basic mechanics in such subinvolution is most likely poor contractility of the uterine muscle.

The coexistence of pregnancy and tuberculous endometritis is exceedingly rare. However, I observed this some years ago in a sixteen year old colored primigravida who was admitted to University Hospitals of Cleveland in a terminal state, with fever to 40°C., uterine bleeding and generalized sepsis, nine days after a spontaneous complete abortion at six months. The patient expired of miliary tuberculosis on her seventh hospital day, her temperature having remained between 39 and 40°C. during her hospital stay. Examination of the uterine material revealed tuberculous endomyometritis. (Fig. 14.) In retrospect it appears that the patient developed fulminating disseminated tuberculosis after conception, aborted completely and then expired from the generalized tuberculous process. Tuberculous endomyometritis was the only anatomic cause of the postabortal bleeding which could be established. Permission for necropsy was not granted.

**Retrodisplacements.** In speaking of secondary postpartum hemorrhage Kerr<sup>53</sup> states, "In a few cases I have seen a very profuse hemorrhage occur in the third or fourth week of the puerperium, when the patients were going about, and in which apparently the only cause was a backward displacement of the uterus." While it is true that retrodisplacement of the puerperal uterus may exist without associated or antecedent pathologic conditions, it is



FIG. 14. Photomicrograph showing tuberculous endometritis; specimen removed because of secondary postabortal bleeding nine days after spontaneous late abortion. Note tuberculous granulation tissue and tubercle formation. Tubercle bacilli verified by acid-fast stains.  $\times 40$ . (Specimen of courtesy Howard T. Karsner, M.D.)

often found to be associated with subinvolution, retention of placental tissue, faulty involution of the placental site or endometritis. The mechanism of bleeding in uncomplicated cases is passive congestion or pelvic vascular engorgement; the arterial blood is delivered with the normal *vis a tergo* whereas there is impaired venous drainage. Such uncomplicated cases usually respond satisfactorily to the timely use of a properly fitting vaginal pessary, a course of oxytocics, hygroscopic (boroglycerine) vaginal suppositories and hot vaginal douches provided, of course, the cervix is closed. The use and abuse of pessaries has been taken up elsewhere.<sup>54</sup>

**The Postcesarean Uterus.** In a consideration of the subject of secondary puerperal hemorrhage special consideration should be given the postcesarean uterus. The reason for which the cesarean was performed may predispose to late bleeding; for instance, blood-infiltrated myometrium from a case of *ablatio placentae*, which perhaps should have had cesarean-hysterectomy rather than simple hysterotomy, may have considerable difficulty contracting and retracting postpartum, with protracted delayed bleeding, as a result of atony. Late bleeding of a serious degree may emanate from a sinus in the lower

segment where a placenta previa had been situated. Many obstetricians have found the almost routine packing of placenta previa patients delivered by abdominal section to be a reliable prophylaxis against both immediate and delayed bleeding from lower segment and cervical sinuses. Blood loss and uterine atony create a vicious circle: The greater the blood loss, the greater the tendency to atony; contrariwise, the more profound the atony, the greater the blood loss. Hence failure to make adequate blood replacement in patients who have bled either before or after cesarean section increases the liability to postpartum hemorrhage, delayed as well as immediate.

Of particular interest is the phenomenon of delayed hemorrhage from the cesarean incision itself. Although failure to achieve adequate hemostasis in closing the hysterotomy incision usually demands attention within the first six to twelve hours postpartum, it occasionally happens that secondary bleeding will not become manifest until several days after surgery. This may be due to the breaking off of a thrombus which had temporarily maintained hemostasis or it may be due to the premature digestion of the suture material used in closing the incision. Premature solution of suture material notoriously occurs in the event of infection along the suture line. The avoidance of infection and the meticulous attention to hemostasis cannot be overemphasized.

In a report on cesarean section at the Boston City Hospital the authors<sup>55</sup> encountered twenty-three maternal deaths in their series of 961 cesarean sections or a percentage of 2.4. Of the twenty-three deaths one was ascribed to secondary hemorrhage on the twenty-third postpartum day. This patient had had several previous bouts of uterine bleeding before the fatal episode and, as stated in retrospect by the authors, should have had a hysterectomy early in the puerperium. Regarding the prevention of secondary hemorrhage after cesarean section the

authors state, "One must be sure there is no chance for secondary hemorrhage either from uterine atony or from improper hemostasis before the abdomen is closed." Autopsy in the fatal case just reported<sup>55</sup> showed three large open sinuses at the placental site; the cause of death was evidently faulty involution of the placental site.

*Puerperal Inversion of the Uterus.* This may be a cause of serious secondary postpartum hemorrhage. Of twenty-four cases of puerperal inversion recently reported,<sup>56</sup> three were characterized by secondary hemorrhage. The first patient continued to bleed moderately postpartum and had difficulty in voiding. While straining in the bathroom on the seventh day the complete uterus came out of the introitus. The second patient experienced a sudden hemorrhage on the fourteenth day following a spontaneous delivery. Examination upon return to the hospital, with admitting diagnosis of "placental polyp," revealed an inverted uterus which was quite easily replaced by vaginal manipulation under anesthesia. The third patient experienced immediate postpartum hemorrhage for which transfusions were given. Despite recovery from the immediate hemorrhage the patient continued to bleed excessively and when seen by a consultant six weeks postpartum, showed a chronic inversion which, also, was replaced by taxis *per vaginam*.

Just as concealed inversion is a not uncommon cause of immediate postpartum hemorrhage, so inversion which escapes recognition at the time of delivery may later manifest itself by secondary hemorrhage. Although the fundamental cause of inversion of the uterus is not known, surely a thoughtful management of the third stage of labor is important in its prophylaxis. Forceful downward pressure on a soft fundus in an attempt to separate the placenta invites inversion.

*Ruptured Uterus.* Although the incidence of rupture of the uterus as encountered at University Hospitals of Cleveland<sup>57</sup>

was found to be only one case in every 2,756 deliveries, I believe that the occurrence of this accident is considerably more common although perhaps not recognized. Just as a certain percentage of cases of unexplained immediate postpartum hemorrhage are doubtless due to unrecognized uterine rupture, so it appears most tenable that a small percentage of cases of persistent or recurring late bleeding are associated with occult uterine rupture.

I recall two interesting cases in which the patients were delivered by internal podalic version and breech extraction. There was no immediate evidence of undue postpartum hemorrhage. However, both patients had persistent bleeding during the early puerperium with morbid courses and, after about two weeks, the development of a broad ligament abscess. Extraperitoneal drainage of the broad ligament accumulation of exudate in each case revealed an infected hematoma. In reviewing the sequence of events it appears quite patent that each patient sustained an incomplete concealed rupture of the lower segment, with extravasation of blood into the adjacent broad ligament. The advisability of immediate exploration of the uterine cavity after difficult version or breech extraction and in cases in which the operator encountered difficulty in the classical application of the anterior blade of the Kielland forceps, may have much to commend it.

*Aneurysm of the Uterine Artery.* Although exceedingly rare, the rupture of a traumatic aneurysm of the uterine (or coronary) artery (Fig. 15) may cause sudden exsanguinating hemorrhage. The latter may occur spontaneously or may follow the slightest straining in the puerperium. Practically any injury to the uterine artery may result in aneurysm formation. Such traumas include (1) inept forceps operations; (2) extensive cervical lacerations or incisions; (3) version and extraction; (4) breech extraction and (5) lower segment cesarean section. A cervical tear or incision which extends into the lower uterine segment (incomplete uterine rupture) may

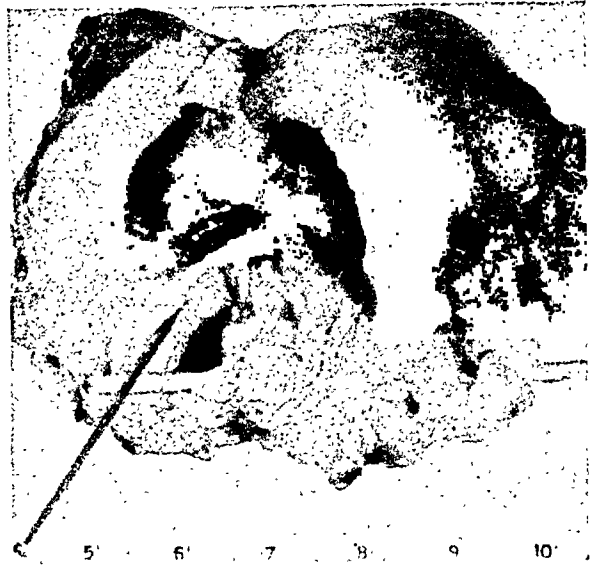


FIG. 15. Aneurysm of uterine artery; orange stick demonstrates communication between uterine artery and aneurysm sac. Late hemorrhage from uterine artery aneurysm is exceedingly rare nowadays but used to be fairly common in the era of accouchement forcé and the Bossi dilator when such were widely employed in the management of placenta previa and eclampsia. (Specimen courtesy of Herbert F. Traut, M.D.)

involve the uterine artery, with subsequent aneurysm formation and eventual rupture.

Vogelsanger<sup>58</sup> reported a case which followed version and extraction for possible placenta previa. The puerperium was uneventful for the first week; severe bleeding began on the eighth day and continued for two weeks. At hysterectomy the source of bleeding was found to be a small ruptured aneurysm of one uterine artery. Vogel-sanger refers to a similar case in the literature in which hemorrhage occurred on the nineteenth and twenty-first days; at laparotomy the affected uterine artery was transfixed and recovery ensued.

### *The Uterine Adnexa*

Late postpartum hemorrhage arising from pathologic conditions in the adnexa is exceedingly rare. However, abnormal uterine bleeding rather frequently accompanies puerperal pelvic peritonitis and adnexitis. Inflammatory involvement of the ovaries brings about interference with the normal development of the graafian follicle and

corpus luteum, with resulting erratic and frequently profuse and prolonged bleeding.

The ovarian tumors which may cause bleeding late in the puerperium are in general of two types: First, there are the corpus luteum cysts which are thought to result from the gradual resorption of blood elements in corpus luteum hematomas. Occasionally these cysts are encountered in the postpartum period. They are characteristically soft and painless and tend to fluctuate in size from one examination to the next. Once in a great while they may be the source of functional bleeding which may be so persistent as to require surgical ablation. The second group of ovarian tumors to be considered includes those which are estrogen-secreting in their physiologic behavior; although rare in the child-bearing period, granulosa and theca cell tumors do occur. Although the diagnosis of granulosa or theca cell tumor is usually not really made until laparotomy, the importance of detecting and following adnexal masses cannot be overemphasized.

#### THE CENTRAL NERVOUS SYSTEM

This article would be incomplete without some mention of the possible role of neurogenic and psychogenic factors in the etiology of bleeding late in the puerperium.

Theobald<sup>59</sup> believes that vegetative control over the genital functions resides in a hypothalamic center and that menstrual abnormalities in general are reactions of this center transmitted by its neurologic connection to the hypophysis. According to Von Raisz<sup>60</sup> head trauma can cause hyperestrinism, with resulting endometrial hyperplasia and menorrhagia. Muller<sup>61</sup> studied the effect of the high altitude of a resort on young women and observed menstrual abnormalities of various sorts. Many waitresses found it necessary to return to lower levels because of serious menorrhagia. Muller hypothesized that the primary effect of high altitude is upon the hypophysis but he considered the possible influence of increased ultraviolet radiation and decreased oxygen supply upon the

vessels of the endometrium. From the foregoing it is at least quite suggestive that the central nervous system is responsive to various stimuli, from head trauma to high altitude, and that a common reaction to physical agents is menorrhagia.

Miller<sup>62</sup> maintains that the majority of menorrhagias are psychogenic and that the chemical disturbance is secondary to a psychic factor acting on the endocrine glands. Markee<sup>63</sup> showed experimentally that endometrium transplanted intraocularly will show secondary hemorrhage in monkeys frightened late in the menstrual period. Emotional stress, anxiety and feelings of resentment are not infrequently expressed in the symptom of uterine bleeding. With the emotional lability and frequent psychic "let-down" so often observed in the puerperium, the stage is set for the burgeoning of certain psychosomatic responses of which abnormal uterine bleeding is not uncommon.

The psychological studies of several investigators including Novak and Harnik<sup>64</sup> have disclosed that the usual dynamics for abnormal uterine bleeding of psychogenic origin are a deep-seated aversion to coitus and morbid fear of pregnancy. These psychologically conditioned bleeding episodes in the puerperium are probably not dissimilar in origin to the occasionally observed premature onset of bleeding experienced by brides. Surely, women in protest against imminent biologic processes can develop a galaxy of symptoms of which unnatural uterine bleeding is not the least. However, it would be wrong to assign the cause of abnormal uterine bleeding in the puerperium to psychogenic factors by simply excluding the many organic disorders which have been found capable of evoking such bleeding; for in addition to excluding organic causes it is essential that adequate psychic dynamics be established, that is, it must be a definitely positive diagnosis.

In no specialty in the practice of medicine is psychological awareness more essential than in the discipline of obstetrics and

gynecology. To those of us who pursue the healing art even in this twentieth century the criticism voiced by Socrates<sup>65</sup> against the physicians of two and a half millenia ago may still be germane: "For this is the great error of our day in the treatment of the human body, that physicians separate the soul from the body."

## SUMMARY

An effort has been made to review the general subject of late postpartum hemorrhage and to scrutinize the great variety of pathologic entities which may be involved in this serious obstetrical complication concerning which little has been written in a comprehensive way. The importance of considering general systemic disorders and neuropsychiatric factors as well as the gamut of purely gynecic lesions and aberrations has been emphasized. Although therapeutic suggestions appear throughout the article, it is beyond the scope of this paper to take up the management of the numerous pathologic conditions which may be involved in instances of delayed hemorrhage postpartum or postabortum. Emphasis has been placed throughout on a consideration of the natural history of the various morbid conditions, with a view to prophylaxis wherever possible; early diagnosis and, accordingly, prompt and adequate intervention. No phase of obstetric practice is more important than an appreciation of the factors involved in the care of women with late postpartum hemorrhage.

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# HEXYLCAINE HYDROCHLORIDE\*

## A PRELIMINARY REPORT OF ITS CLINICAL USE IN COMPARISON WITH PROCAINE

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WHILE the drugs now in common use for block anesthesia are quite satisfactory, the search continues for an even better agent. Clinical trial of hexylcaine hydrochloride since April, 1948, has shown it to have sufficient promise to warrant a preliminary report. We have now used the drug as a spinal anesthetic in more than 100 patients and our experiences form the basis of this paper.

Hexylcaine hydrochloride (1-cyclohexylamino-2-propylbenzoate hydrochloride) has a molecular weight of 297.85 and is freely soluble in water. A 1 per cent aqueous solution has a pH of 4.4 (unbuffered) and is stable under conditions of boiling and autoclaving. Beyer, Latven and Freyburger<sup>1</sup> have compared its toxicity to that of other local anesthetic agents in laboratory animals and concluded that when injected intravenously or subcutaneously, the toxicity of hexylcaine in animals is greater than that of procaine and less than that of metycaine.

Wylde, Waters and Orth<sup>2</sup> have used it for spinal anesthesia in forty cases. Anesthesia was slow in onset and the level was difficult to control. This may have been due to their use of the 0.5 and 1 per cent solutions rather than the crystalline drug restored with glucose. There were no instances of irreversible nerve changes after using the agent.

In our first few cases the crystalline drug was dissolved in cerebrospinal fluid and injected in the same manner but in smaller doses than we customarily use with procaine. Because the level of the resulting

anesthesia was uncontrollable and often went too high, we assumed that in some spinal fluids the drug was isobaric or even hypobaric. Weighting the drug with glucose overcame this difficulty and this method has been employed in all subsequent cases.

Our technic for single dose spinal anesthesia consists of dissolving a 50 mg. ampule of the crystalline drug in 2 ml. of 10 per cent glucose. The desired dose is drawn into a syringe and diluted with spinal fluid in sufficient amount to lower the glucose concentration to 5 to 7 per cent in the injected mixture. This is then injected subdurally through the second, third or fourth lumbar interspace, depending on the desired level of anesthesia. Our dosage has ranged from 15 mg. to 50 mg., depending on the site of the operation and the condition of the patient. In Table 1 are shown the thirty-two spinal anesthetics out of the total of 100 in which 15 to 20 mg. of hexylcaine were used. Muscle paralysis in the legs was not complete in a few cases but it was not necessary to supplement the anesthesia in any of these thirty-two cases. Rectal relaxation was excellent in the fifteen cases in which ano-rectal surgery was done.

In order that the reader may have a basis for comparison we have included in Table 1 the thirty-three cases from the procaine series in which 60 mg. or less of the drug were used.

We have not found it necessary to give more than 50 mg. in a single dose spinal anesthetic even for operations on the gall-

\* From the Division of Anesthesiology of the Philadelphia General Hospital, Philadelphia, Pa. Hexylcaine hydrochloride was supplied under the trademark Cyclaine through the courtesy of the Department of Medical Research, Sharpe and Dohme, Inc.

bladder and stomach. We ordinarily use a total volume of 4 ml. for surgery above the umbilicus and 1 to 3 ml. below this level.

To minimize the dosage, an attempt is made to localize the injected spinal anes-

thetia can be detected at the height at which anesthesia is ultimately desired. This ordinarily takes three to five minutes although we have seen anesthesia develop in less than one minute or not appear for as long as fifteen. The table is then levelled

TABLE I  
CASES IN WHICH LESS THAN 20 MG. OF CYCLAINES OR 60 MG. OF PROCAINE WERE USED

Operative Site	Total No. of Cases	No. Using Small Doses	Dose		Age		Physical Status*	
			Average	Range	Average	Range	Average	Range
Cyclaine								
Anorectal.....	15	11	16.7 mg.	15-20 mg.	41.8	22-67	1.88	1-2
Lower extremities.....	46	21	16.1 mg.	13-20 mg.	65.8	50-84	3.42	3-4
Total.....	61	32						
Procaine								
Anorectal..	27	17	50 mg.	50 mg.	32.4	21-85	1.7	1-3
Lower extremities.....	22	13	45.3 mg.	30-50	62.4	26-79	3.1	2-4
Perineal gynecologic.....	3	3	50	50	29	17-45	2.3	2-3
	52	33						

\* The figures under the heading Physical Status refer to those given by the American Society of Anesthesiologists in categories 1 to 4 in which 1 is the best physical status and 4 is very poor physical condition.

thetic agent around the nerve roots supplying the area in which anesthesia is desired. With this in mind the anesthetic agent is injected with the patient level. The table

TABLE II  
AGE GROUPS  
SHOWING AGE DISTRIBUTION OF PATIENTS GIVEN SPINAL ANESTHESIA WITH PROCAINE AND WITH HEXYLCAINE

Age	Hexylcaine	Procaine
10-19	7	12
20-29	10	17
30-39	16	20
40-49	17	22
50-59	21	12
60-69	14	11
70-79	12	5
More than 80	3	1
	100	100

is then tilted slightly in the direction in which we want the solution to concentrate. In abdominal surgery it is placed in 5 to 10 degrees Trendelenburg until the level

and the height of anesthesia will be at the desired level by the time the skin has been prepared and the drapes placed. For operations on the lower extremity the solution is injected subdurally with the patient lying on the affected side. He is kept on that side for three to five minutes, or until adequate anesthesia develops, and is then placed in any position necessary for the operation.

As a basis for comparison we have taken 100 cases of spinal anesthesia in which procaine was used as the agent. These cases were picked at random from our Chicago Keysort<sup>3</sup> files during the same period of time in which we were trying hexylcaine. By taking the same period for the two series we believe the variables such as surgeons, operative technics and anesthesiologists will be equalized.

In Table II we have shown the age distribution in the two groups of patients to indicate that the patients in the two series were comparable. The average age of the

patients given procaine spinal anesthesia was 42.5 years while that of those given hexylcaine was 48.5.

Additional intravenous vasopressor for spinal hypotension was required by 12 per cent of the procaine group and by 21 per

cases in each series according to the region of operation. It will be noted that the dose of hexylcaine was in most cases about one-third that of procaine. Due to the pressure of clinical work it has not been possible to follow-up all the patients on the wards

TABLE III  
COMPARISON OF PROCAINE AND HEXYLCAINE

Regions	Procaine				Hexylcaine			
	No. of Cases	Average Dose mg.	Average Duration Minutes*	Average Physical Status†	No. of Cases	Average Dose mg.	Average Duration Minutes*	Average Physical Status†
Upper abdominal								
1. Gallbladder.....	1	150	115	3	1	50	40	3
2. Stomach duodenum.....	1	120	65	3	1	50	55	4
3. Other.....	1	120	0†	4	1	40	45	2
Lower abdominal								
1. Appendix.....	12	135.8	66.8	1.6	10	50	49.5	1.7
2. Bowel.....	1	150	60	2.0				
3. Obstetric operations.....	1	120	80	3				
4. Gynecologic operations.....	5	132	77	2	6	50	85	1.8
5. Others.....	2	135	48	3	3	50	75	2.7
Abdominal wall								
1. Inguinal.....	19	140.5	64	1.5	12	48.3	65.8	1.66
Perineal								
1. Anorectal.....	27	65.5	31.1	1.6	15	19.6	33.8	1.7
2. Perineal genitourinary.....	5	131.0	59	2.0	2	31	60	2.5
3. Perineal gynecologic.....	3	67.5	34.5	2.5	3	37.6	83.3	2
Limbs								
1. Lower soft.....	4	98.7	49	1.2	9	21.7	48.0	2.7
2. Lower bones.....	18	59.3	38.5	3.1	37	24.7	41.4	2.0

\* Duration is from injection of anesthesia to completion of operation

† Spinal failure

‡ See footnote Table I

cent of the hexylcaine series. Although we have no means of measuring this, we have been interested to hear several of the surgeons remark on the completeness of the abdominal muscle paralysis which spinal anesthesia with hexylcaine provides. Epinephrine, 0.5 mg., was added to the spinal anesthetic solution to prolong the anesthetic time in 56 per cent of the procaine series and 7 per cent of the hexylcaine series. In order to complete the operation, supplementary agents other than dilute pentothal were added to 6 per cent of the procaine group and to 2 per cent of the clycaine series.

In Table III we have grouped the 100  
*December, 1949*

after operation to find out exactly when the spinal anesthesia wore off. It is our impression from observation in the operating rooms and on the wards that in the doses given spinal anesthesia with hexylcaine lasts sixty to ninety minutes.

We have also used hexylcaine in fifteen fractional spinal anesthetics with the catheter technic described by Touhy<sup>4</sup> and the modification for segmental spinal anesthesia described by Saklad et al.<sup>5</sup> Our present method is to dissolve 150 mg. of hexylcaine crystals in 6 ml. of 10 per cent glucose and dilute the mixture to a volume of 10 ml. with spinal fluid. This makes a concentration of 1.5 per cent or 15 mg. per

ml. We use an initial dose of 15 to 30 mg. and usually give 15 mg. every twenty to thirty minutes after the first half hour. The smallest dose by this technic was 30 mg. for a ninety-minute supravaginal hysterectomy in a forty-six year old patient; the largest dose was 135 mg. in two hours thirty-five minutes in a fifty-two year old patient for exploration of the common bile duct. By comparison, a 100 minute supravaginal hysterectomy in a sixty-two year old patient required 250 mg. of 5 per cent procaine and a colectomy in a sixty-two year old man required 500 mg. of 5 per cent procaine in two hours fifty minutes.

In addition to using hexylcaine for spinal anesthesia we have employed it in over 200 regional and local nerve blocks in concentrations varying from  $\frac{1}{4}$  to 1 per cent. Our impression to date is that it is more effective in weaker concentrations than procaine is. This is in keeping with our results when the drug is used in spinal anesthesia. In a recent brachial block in which 30 ml. of 1 per cent hexylcaine without epinephrine were used, the anesthesia lasted five hours. Following intracutaneous or deep injection some patients complain of mild burning for a short period immediately after injection.

In our experience with this drug to date we have not seen a local or general toxic reaction. There have been no instances of irreversible changes in nerve function.

#### SUMMARY AND CONCLUSIONS

The use of hexylcaine hydrochloride in 100 single dose spinal anesthetics and fifteen fractional spinal anesthetics has been described. The results have been

compared with those of two similar groups in which procaine hydrochloride was used. The use of hexylcaine in local and regional block anesthesia has been mentioned.

Our experience to date indicates that this new drug provides more complete and longer lasting nerve block in smaller doses relative to its animal toxicity than does procaine. For these reasons we believe further clinical trial is warranted. We are continuing our studies and hope that others will try it so that the large amount of data required for the accurate appraisal of a new drug will be amassed.

#### ADDENDUM

*Addendum.* Since this manuscript was submitted for publication, hexylcaine hydrochloride has been successfully used in 400 additional spinal anesthetics. The conclusions reached in this preliminary report remain unchanged by this more extensive experience.

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# DUPLICATION OF THE SMALL INTESTINE\*

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ALTHOUGH considered a rare anomaly duplication of the bowel probably occurs more frequently than has been suspected. Donovan has operated upon six patients in eighteen months and regards it as one of the important causes of massive intestinal hemorrhage in infants. Since almost all duplications produce symptoms of an acute nature, it is essential that the surgeon be familiar with the condition and be prepared to treat it.

*Etiology.* The etiology of intestinal duplication has been the subject of much controversy and many theories have been put forward to explain the anomaly.

Any explanation to be acceptable must account for the fact that duplications occur at all levels of the intestinal tract and that they are always on the mesenteric side of the true bowel situated between the leaves of the mesentery. This rules out the idea that these anomalies are of the same nature as Meckel's diverticulum and are due to persistence of the proximal part of the vitelline duct. In addition cases have been reported by Edwards and by Grove and Porch of duplication occurring when a Meckel's diverticulum was also present on the antimesenteric border of the bowel.

Sequestration of the intestinal epithelium has been suggested by Hughes-Jones as a possible etiologic factor. Lewis and Thyng have demonstrated diverticula occurring along the mesenteric border of the embryonic intestine of various mammals and man. Normally these disappear as development continues but they may persist and be pinched off from the bowel. This explanation accounts for spherical duplications and mesenteric cysts but it is

difficult to see how the long, tubular variety could be produced in this manner.

The entire subject has been thoroughly reviewed by Bremer who considers that the spherical duplications are best explained by the theory of Lewis and Thyng but that the tubular forms are derived from abnormalities in the development of the solid stage of the intestine. In the six-week embryo the intestinal tract undergoes a period of rapid growth and the epithelial cells proliferate to fill the lumen forming a solid cord. This may occur only in isolated regions of the tract. Normally, as growth progresses, vacuoles appear in the solid cord; these fuse to form a lumen. This process has been well demonstrated by Johnson in wax models of the developing intestine. It is easy to see how, by abnormalities of fusion, two, three or even four lumina might be formed. As growth continues, the lumina are separated; and the undifferentiated cells surrounding the epithelium give rise to all the coats of the bowel. This theory explains all the variations thus far reported in clinical cases of intestinal duplication. Atresia and stenosis of the intestine can be accounted for in a similar manner by failure of vacuolization and the persistence of a solid cord for varying lengths of the tube. Duplication is occasionally associated with atresia of the normal bowel, as in Case 1 of the present series, and it is possible that a similar stimulus may initiate both abnormalities. (Fig. 1.)

*Pathology.* Duplication of the intestine may occur anywhere in the tract but it is most common in the ileum. The duplicate bowel lies along the mesenteric border of

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the intestine between the leaves of the mesentery.

The duplicate lumen may communicate with the intestinal tract at one or both ends or not at all. Communication usually occurs at the distal end and proximally the

The reason heterotopic mucosa develops in these anomalous structures is as yet unknown. Taylor has contributed a complete pathologic description of this interesting condition but, as Edwards points out, he underestimates its clinical signifi-

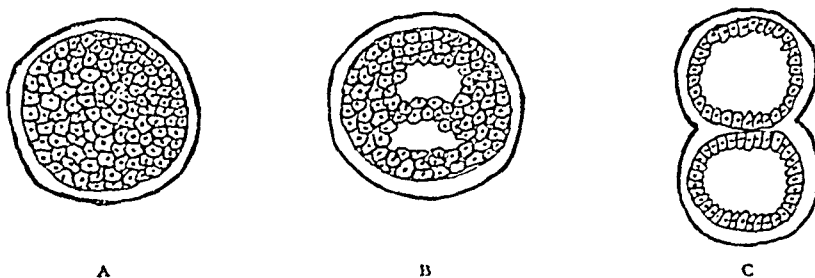


FIG. 1. Diagram of development of duplication of intestine; A, solid stage; B, vacuolization and C, complete duplication.

duplication ends as a blind, rounded tube. It may vary in length from 1 to 120 cm. and it may occasionally exist as several isolated tubular structures lying free within the leaves of the mesentery. (Fig. 2.)

The structure of the duplication is that of normal bowel. The mucous membrane may be gastric or intestinal and the level of the anomaly has no influence on the type of epithelium present. Ectopic gastric mucosa is frequently found.

In some cases the superficial epithelium resembles that of the normal intestine but gastric glands with acid-secreting cells are

found. In this series and in all the others reported ectopic gastric mucosa has usually been associated with peptic ulceration of the intestine at the point of communication. This may lead to the complications of massive hemorrhage or perforation with peritonitis. (Figs. 3 and 4.)

#### CLINICAL FEATURES

Symptoms due to duplication of the intestine commonly occur in infancy or early childhood. In the series reported by Ladd and Gross the age incidence was from two weeks to nine years. Occasionally

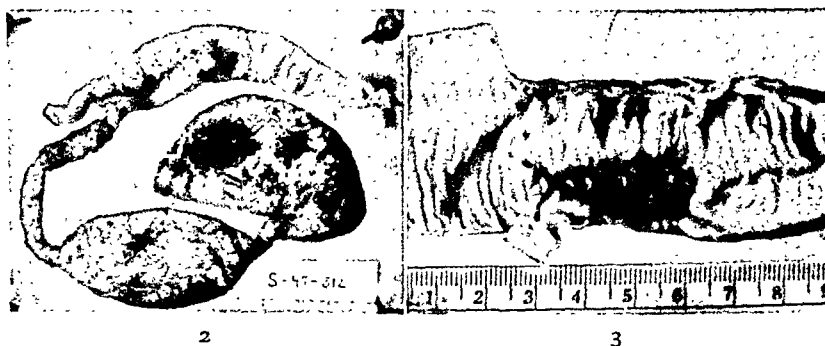


FIG. 2. Specimen of duplicate ileum resected; note the large stomach-like pouch. Case 11.

FIG. 3. Duplicate bowel showing peptic ulceration of mucosa. Case 11.

found in the deep layers. In others the duplication is lined with typical gastric mucosa and sections resemble the stomach. This type may secrete true gastric juice containing the enzymes pepsin and rennin as well as free hydrochloric acid.

symptoms begin at birth. The clinical picture can best be considered under the following headings:

*Intestinal Obstruction.* This may be caused by several factors, namely, by pressure from the increasing size of the dupli-

cation, intussusception and volvulus; the duplication may be associated with intestinal atresia. All of these have been reported in the literature. A palpable mass is usually present and x-ray of the abdomen may show compression of the bowel by an abnormal gas-filled shadow.

*Symptoms Due to Peptic Ulceration.* Intermittent abdominal pain has been reported by Edwards in a case which ultimately perforated necessitating an emergency laparotomy. Diarrhea due to acid irritation of the ileal mucosa occurs quite frequently. Massive hemorrhage is not uncommon. Duplication should always be considered in the differential diagnosis of intestinal bleeding in infants. The surgical procedure involved in dealing with these cases is so serious that exploration should not be attempted until the child has been transfused and brought back to as good a condition as possible. Perforation with local abscess or general peritonitis is a rare complication but has been observed by Edwards and by Black and Benjamin.

#### TREATMENT

The treatment of choice is excision. This always involves resection of the adjacent bowel because the duplication lies between the leaves of the mesentery and cannot be removed without compromising the circulation of the normal intestine. Side-to-side anastomosis is technically easier and safer than end-to-end.

Short-circuiting operations and the creation of windows between duplication and bowel lumen have been tried but usually fail to relieve the symptoms. If gastric mucosa is present, ulceration occurs at the site of anastomosis and symptoms recur. The only effective treatment is complete removal of the anomaly. The difficulties and dangers of bowel resection in infants are well recognized but with careful pre-operative management and massive transfusion the procedure does not carry an excessive mortality. Donovan reports six cases in which all patients survived resection. This article reports on an additional



FIG. 4. Microscopic section through duplication; the two lumina have a common muscular wall with ileal mucosa above and gastric mucosa below on the side of the duplication. Case 11.

four patients, three of whom survived operation.

#### CASE REPORTS

**CASE 1.** F. W. age one day, was admitted to the Children's Memorial Hospital June 25, 1945. This baby was born three hours prior to admission. Abdominal distention was noted at birth and a flat plate of the abdomen showed evidence of small bowel obstruction. The anus was patent. Clinical examination was otherwise negative. Laparotomy was performed eighteen hours post partum and a duplication of the terminal ileum was found which had formed a volvulus around its blind, pouch-like ending. The gangrenous bowel was excised and a side-to-side anastomosis performed. An ileostomy was done to relieve distention. The child died eight hours postoperatively.

The pathologic report (supplied by Dr. F. W. Wigglesworth) revealed that the specimen consisted of a dark, greenish blue length of bowel which was small in diameter at one end and dilated at the other. There was a hemorrhagic, fibrous mesentery attached throughout its entire length and at one point contained what appeared to be another narrow piece of bowel which was curled up on itself. It did not communicate with the true lumen. Sections of the true bowel and the duplication showed normal small bowel structure with intestinal mucosa. The diagnosis was duplication of ileum with volvulus.



CASE II. C. C., age three months, was admitted to the Children's Memorial Hospital November 8, 1945, with the complaint of passage of blood by rectum two weeks prior to admission.

Clinical examination was negative and an exploratory laparotomy was undertaken with a preoperative diagnosis of bleeding Meckel's diverticulum. A duplication of the terminal ileum was found which was resected and the bowel continuity reestablished by a side-to-side anastomosis.

The postoperative course was uneventful. The patient recovered and was discharged from the hospital free from symptoms.

The pathologic report (supplied by Dr. F. W. Wigglesworth) revealed that the specimen consisted of a length of ileum measuring 20 cm. At a point 7 cm. from the distal end it was seen to bifurcate into two portions at its mesenteric border. These were closely applied and ran parallel to one another for a distance of 8 cm. At that point they separated. The duplication continued 11 cm. further, gradually narrowing at its proximal end. Here it widened to form a large fusiform pouch which was symmetrical and measured 10 cm. in length by 5 cm. at its widest point. The distal end of the pouch gave rise to a short narrow portion 3 cm. in length. This opened into another large, purse-like pouch which formed the most proximal part of the diverticulum and ended blindly.

Two ulcers were present in the ileum-like portion situated on the wall which was in apposition to the bowel. The distal pouch contained smooth ileal mucosa with two raised islands of white gastric mucosa. The proximal pouch was lined with gastric mucosa and showed three peptic ulcers.

Fluid aspirated from this proximal pouch showed a free acidity of 30, total acid of 60 and the presence of pepsin and rennin. The diagnosis was duplication of terminal ileum with accessory stomach.

CASE III. E. P. age two and one-half months, was admitted to the Royal Victoria Hospital April 18, 1947, following a massive intestinal haemorrhage one hour prior to admission.

The past history was negative except for sporadic diarrhea for two weeks before onset of the hemorrhage. On admission the child was pale, cold, and almost exsanguinated; the diaper contained a great deal of dark red, clotted blood. Physical examination was other-

wise negative. Blood transfusion was started at once. The child's condition improved remarkably in the next few hours and he was taken to the operating room where under ether anesthesia exploratory laparotomy was performed by Dr. C. A. McIntosh. A reduplication of the terminal ileum was found with the duplicate bowel extending from a point 12 cm. proximal to the ileocecal valve to the jejunum, a total length of 90 cm. The duplicate bowel communicated with the normal lumen at the distal end and at this point a hard, indurated, ulcerated area could be felt.

Because of the child's precarious condition and the great length of the duplication, resection of the entire anomaly was considered too hazardous a procedure. A segment of normal and reduplicated bowel 35 cm. in length was excised. This contained the indurated area and it was hoped that enough gastric mucosa was removed to prevent further ulceration. The intestinal continuity was reestablished by side-to-side anastomosis and enteroanastomosis was performed between the duplication and normal bowel to prevent formation of a blind loop.

The patient's postoperative course was satisfactory for ten days and he was taking fluids well. On April 29th he had a moderate melena and on April 30th there was a fairly massive hemorrhage from the bowel. It was considered that further ulceration had occurred and a more extensive resection was necessary.

On April 30th under intratracheal cyclopropane anesthesia an operation was performed by Dr. C. B. Ripstein. The remaining duplication and the adjacent ileum was resected (55 cm.) and a side-to-side ileocecostomy performed. The immediate postoperative course was satisfactory. Penicillin and streptomycin were given and continuous gastric suction used for forty-eight hours. The patient was then put on feedings of breast milk and took these without vomiting. He began to pass frequent, watery stools on the third postoperative day and continued to pass from four to six stools daily. These contained digested food material and no blood. Hydration was maintained with difficulty by frequent clyses of normal saline and plasma. Despite adequate oral intake supplemented by parenteral feedings and vitamins the child lost weight steadily.

On May 12th the diarrhea became more profuse and the temperature was elevated to 100°F. Culture of the stools revealed a profuse

growth of salmonella. Streptomycin was given and the electrolyte and water balance maintained by intravenous infusions and the child improved. However, his nutrition could not be maintained. Over the period of the next month his condition gradually deteriorated and his weight dropped to 8 pounds from an initial weight of 11 pounds 3 ounces. The child expired June 28, 1947, from a terminal staphylococcal bacteremia and septicemia.

Postmortem examination showed extreme inanition. The residual small bowel measured 60 cm. in length.

The pathologic report (supplied by Dr. T. R. Waugh) revealed that the surgical specimen consisted of 90 cm. of small bowel. Seven cm. above the distal end of the specimen the bowel bifurcated and became a double structure; the smaller loop coursed within the mesentery of the larger, the junction between the two being on the mesenteric border of the larger loop.

Immediately beyond the point where the two loops joined the wall of the ileum was thickened and there was an irregular ulcer 1 by  $\frac{1}{2}$  cm. with indurated, heaped up margins.

Sections through the two lumina at the point farthest from their juncture showed that the ileum consisted of a thin walled structure with normal architecture and lined by glands showing the usual pattern. The duplication showed a mucosa consisting of tall, superficial villous folds lined by columnar epithelium and resembling those of normal ileum. The deeper part of the mucosa contained tubular glands



FIG. 5. Specimen resected; complete reduplication on mesenteric side of ileum. Case III.

similar to those found in gastric mucosa and lined with numerous acid cells.

Sections through the point of juncture of the two loops showed a spur covered on one side by the typical gastric mucosa with glands containing many acid cells. This was abruptly replaced at the apex of the spur by normal ileal mucosa which showed peptic ulceration and diffuse infiltration with round cells, polymorphonuclears and eosinophiles. The diagnosis was duplication of the ileum lined by heterotopic gastric mucosa and peptic ulcer distal to junction. (Figs. 5, 6 and 7.)

CASE IV. D. D., age six days, was admitted to the Children's Memorial Hospital, June 9, 1947. This child was born June 2, 1947, and vomited immediately after birth. Blood and



FIG. 6. Section through duplication; the mucosa shows superficial intestinal epithelium and villi with deep, gastric-type glands. Case III.



FIG. 7. Section through spur at juncture of true and duplicate lumina; transition between ileal and gastric mucous membranes. Case III.

mucus were passed in the meconium in the following three days and on examination a mass was felt in the abdomen. X-ray examination showed evidence of obstruction in the upper small bowel and laparotomy was performed.

At operation a volvulus of the jejunum associated with a duplication was found 17 inches from the duodenojejunal junction. In addition a fibrous atresia of the jejunum was present. The volvulus was resected and intestinal continuity restored by side-to-side anastomosis. The patient's postoperative course was somewhat stormy but the child made an eventual complete recovery.

The Pathologic report (supplied by Dr. F. W. Wigglesworth) revealed that the specimen consisted of 30 cm. of jejunum. Three cm. from the proximal end there was a narrowing of the lumen with a diameter of 0.2 cm. Between the layers of the mesentery there was an oval, cyst-like duplication which did not communicate with the intestine. Microscopic sections showed that the duplication contained all coats of normal bowel but the epithelium was flattened and its structure indefinite. The diagnosis was duplication of jejunum with volvulus.

#### COMMENT

These cases represent fairly typical examples of the clinical pictures produced by duplication of the small bowel. Bleeding was present in three cases and intestinal obstruction in two.

Case III presents several interesting problems. The child survived operation immediately but the resection was too extensive (90 cm. of small bowel) to permit proper nutrition and the child ultimately died of inanition complicated by secondary bacterial infection. Digestion was normal but absorption was inadequate and the technical difficulties of long-continued parenteral feedings in a three month old baby made it impossible to maintain life longer than two months. Donovan reports a case in which the patient survived resection of 45 cm. of ileum but no reports could be found of any more extensive resections in infants.

Case II has been carefully studied by Dr. F. W. Wigglesworth, pathologist to the Children's Memorial Hospital, Montreal.

His observations on the acid and enzyme content of the juice aspirated from the duplication present a unique contribution to our knowledge of the pathologic physiology of this anomaly.

#### SUMMARY

1. Four cases of duplication of the small intestine are presented; successful resection was carried out in two. One patient survived operation immediately but died of inanition due to lack of intesting absorption and the fourth patient died eight hours postoperatively.

2. The etiology, pathology and clinical features of the anomaly are reviewed and the fact is reemphasized that it must be considered in the differential diagnosis of intestinal hemorrhage and obstruction in infants.

I would like to record my thanks and appreciation to Drs. C. A. McIntosh, A. K. Geddes and D. E. Ross for their help in the preparation of this paper.

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# SPINAL ANESTHESIA UTILIZING PONTOCAINE IN HYPOBARIC SOLUTION FOR SURGICAL PROCEDURES ON THE ANORECTAL REGION\*

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ANESTHESIA for surgical procedures in the anorectal region often presents a problem to which there is no entirely satisfactory solution. Various techniques of general and regional anesthesia have been employed by anesthetists and surgeons in attempts to overcome the difficulties inherent in the prone position, namely, flexion of the patient, the necessity of providing both sensory anesthesia and relaxation of the anal sphincter, the maintenance of efficient circulatory and respiratory function and, on a busy surgical service, the accomplishment of these tasks with a minimum expenditure of time. It is the purpose of this communication to redirect attention to a technic, previously described by Lund and Rumball<sup>1</sup> but insufficiently utilized by the profession, that may offer an approach to the solution of these problems. The present series of spinal anesthetics utilizing pontocaine in hypobaric solution for surgical procedures involving the anorectal region is far too limited numerically to permit statistical evaluation. The results to date have been encouraging, however, and suggest that the method warrants further investigation.

The extent of spread of an anesthetic solution within the confines of the subarachnoid space is governed by a number of factors.<sup>2</sup> Of these the controllable factors that are of most importance in limiting the extent of anesthesia are the difference in specific gravity between the injected solution and the cerebrospinal fluid and the position of the spinal canal

at the time of injection. These facts have been well demonstrated by Sise,<sup>3</sup> employing hyperbaric solutions, and both Etherington-Wilson<sup>4</sup> and Jones,<sup>5</sup> employing hypobaric solutions. Lund and Cameron<sup>6</sup> have utilized pontocaine in hypobaric solution for spinal anesthesia, employing what they have termed a modified Howard Jones technic. More recently Lund and Rumball<sup>1</sup> reported the use of spinal anesthesia utilizing pontocaine in hypobaric solution for dealing with surgical procedures on the posterior aspects of the lumbar and sacral regions. They refer to this method as the prone technic since the patient is placed prone and flexed at the hips and the subarachnoid injection is performed in this position. Lund<sup>7</sup> now adds small quantities of a vasoconstrictive substance (epinephrine or neosynephrine) to the pontocaine solution in order to obtain more prolonged anesthesia but this should certainly be unnecessary for the type of surgical procedure to be discussed in this communication.

The theoretical advantages accruing from the use of this prone technic of spinal anesthesia utilizing pontocaine in hypobaric solution for surgical procedures on the anorectal region are numerous. The patient is in the optimal position at the time that lumbar puncture is performed and no additional time must be spent in placing the patient in position for the surgical procedure. The rapid onset of sensory analgesia allows the surgical intervention to be begun immediately. The definite limitation of the extent of the anes-

\* From the Surgical Service, U. S. Veteran's Hospital, Newington, Conn. and the Department of Anesthesiology, Hartford Hospital, Hartford, Conn. Published with permission of the Chief Medical Director, Department of Medicine and Surgery, Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the author.

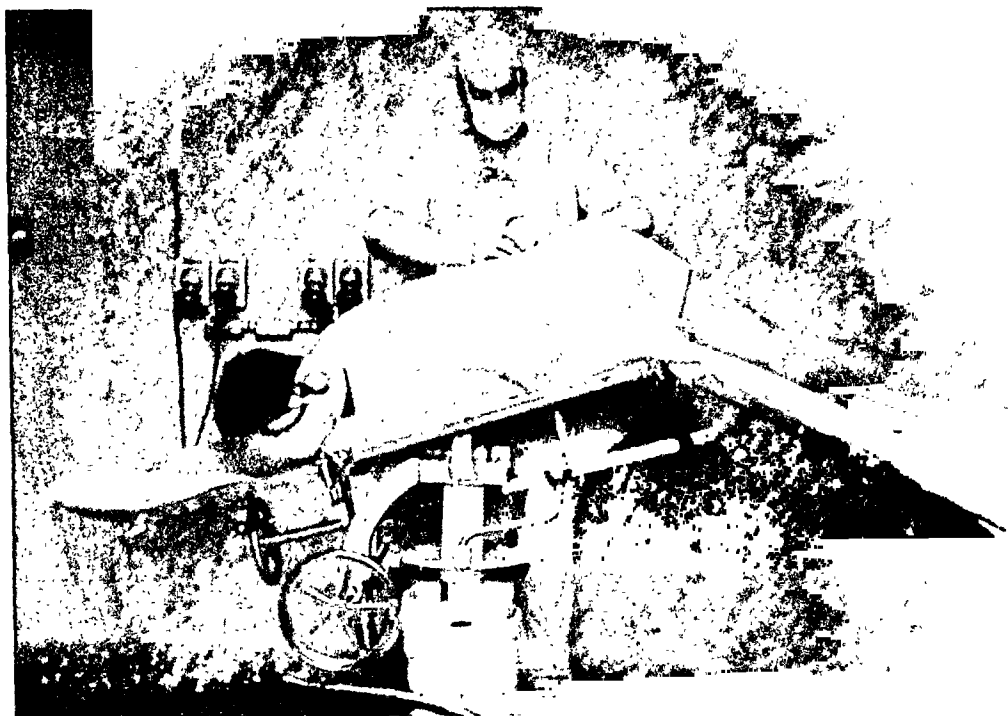


FIG. 1. The patient is placed prone upon the operating table and then flexed 30 to 40 degrees at the hips. A pillow, hidden by drapes in the illustration, is put under the pelvis and lower abdomen to reduce the normal lumbar lordosis. Lumbar puncture is then performed.

thetia to the lumbosacral dermatomes ensures an absence of circulatory depression in the majority of instances. Adequate anal sphincter relaxation is assured by the efficient concentration of the anesthetic solution in the area providing motor innervation to the sphincters. Motor power to the lower extremities remains intact due to the limitation of anesthesia, permitting immediate ambulation upon completion of the surgical procedure, thereby minimizing postoperative vascular and respiratory complications.

These various considerations prompted a limited investigation of Lund and Rumball's prone technic of spinal anesthesia utilizing pontocaine in hypobaric solution for surgical procedures on the anorectal region.

#### TECHNIC

The patient is placed prone upon the operating table and then flexed 30 to 40 degrees at the hips. (Fig. 1.) A pillow under the pelvic brim and abdomen aids materially in reducing the normal lumbar

lordosis and thus facilitates the performance of lumbar puncture. The actual insertion of the needle into the subarachnoid space is performed very slowly and carefully to enable the anesthetist to feel the needle traverse the dura. When the needle is felt to "click" through the dura, the stilet is withdrawn and the patient is asked to contract the abdominal muscles; this straining often will force cerebrospinal fluid out of the needle. Sometimes even this maneuver will fail to produce fluid even though the anesthetist may be certain that the needle is properly placed within the subarachnoid space. On such occasions aspiration with an empty syringe may reveal cerebrospinal fluid and confirm the proper position of the needle. Lumbar puncture is performed with the bevel of the spinal needle turned laterally but the bevel is turned caudad prior to subarachnoid injection of the anesthetic solution. The performance of lumbar puncture in the prone, flexed position is the major difficulty encountered in carrying out this technic, and it is difficult, some experience

being required before it can be performed with facility.

One-tenth per cent pontocaine solution is prepared by withdrawing 1 cc. (10 mg.) from a 2 cc. (20 mg.) ampule of 1 per cent pontocaine and adding to it 9 cc. of triple-distilled water withdrawn from a 10 cc. ampule. It is imperative that these measurements are absolutely correct and that the two fluids are then properly mixed. The solution may also be prepared by adding triple-distilled water to pontocaine crystals. Recently 0.1 per cent pontocaine solution was made available for research purposes in 20 cc. ampules containing 20 mg. of pontocaine. The specific gravity of cerebrospinal fluid varies between 1.004 and 1.006 under conditions of normal health.<sup>8</sup> The specific gravity of 0.1 per cent pontocaine solution is 1.002 at room temperature (24.4°C.). The dose employed varies with the extent of the surgical procedure. (Table I.) As little as 4 mg. of pontocaine may be sufficient for the removal of external hemorrhoidal tabs whereas 8 mg. of pontocaine may be required for an extensive excision of a large pilonidal sinus. Injection of the anesthetic solution is performed very slowly (10 to 20 seconds) at an even rate in order to prevent undue mixing with the cerebrospinal fluid and to allow the anesthetic solution to float along the posterior aspects of the subarachnoid space.

#### RESULTS

Spinal anesthesia utilizing pontocaine in hypobaric solution was employed successfully in seventy-five instances for surgical procedures on the anorectal region and was attempted but abandoned in five other instances. The average patient was a healthy, young, adult male veteran. Therefore, there was little opportunity in this series to evaluate the use of the technic in poor risk patients requiring this type of surgical intervention. Four patients were in the second decade of life, forty-eight in the third, sixteen in the fourth, three in the fifth and four in the sixth. The sex distribu-

tion within the series was unequal, there being seventy-four male patients and one female patient.

The types of operation performed, their relative incidences and the dosages employed are shown in Table I. It should be

TABLE I  
CORRELATION OF DOSAGE EMPLOYED WITH THE TYPE OF  
OPERATIVE PROCEDURE

Operative Procedure	No. of Patients and Dosage Employed					
	4 mg.	5 mg.	6 mg.	7 mg.	8 mg.	Total
Hemorrhoidectomy	2	8	19	1	1	31
Fistula-in-ano....	1	4	5	1	0	11
Pilonidal cyst/sinus	0	4	16	6	2	28
Perirectal abscess..	0	0	3	0	0	3
Miscellaneous.....	1	0	1	0	0	2
Total.....	4	16	44	8	3	75

noted that hemorrhoidectomies and excisions of pilonidal cysts and sinuses made up the great bulk of the surgical procedures. The time necessary to mix the hypobaric solution of pontocaine, perform lumbar puncture and administer the anesthetic solution is shown in Table II. The

TABLE II  
TIME REQUIRED FOR THE ADMINISTRATION OF ANESTHESIA

Minutes	No. of Patients
3	7
4	7
5	11
6	22
7	10
8	6
9	4
10 or more	8
Total	75

average time necessary to accomplish these duties was six minutes which approximates the time necessary for the administration of a spinal anesthetic with the patient in either a lateral or sitting position. The time necessary for the onset of analgesia after the administration of the anesthetic solution is shown in Table III. The average time was three to four minutes which is considerably less than that necessary for the onset of analgesia and fixation of the intrathecally-placed anesthetic solution be-

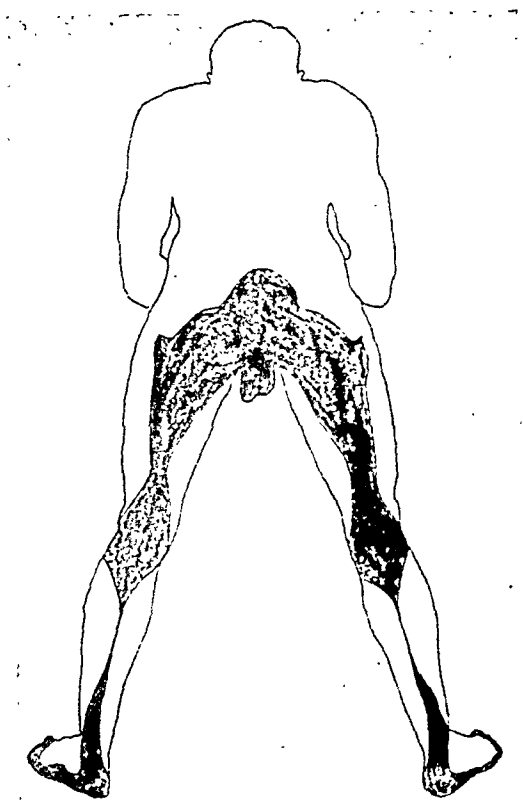


FIG. 2. Area of anesthesia.

fore the patient can be positioned and surgery begun after the ordinary spinal anesthetic. This constitutes an important advantage of the hypobaric pontocaine technic since the patient is already in the optimal position and the surgical procedure may be begun immediately following the onset of analgesia.

TABLE III TIME OF ONSET OF ANALGESIA FOLLOWING THE ADMINISTRATION OF ANESTHESIA	
Minutes	No. of Patients
2	14
3	26
4	25
5	6
6	1
7 or more	3
Total	75

The extent of the anesthesia was usually limited to the "saddle-seat" area. (Fig. 2.) In the majority of instances the upper level of anesthesia was below the fifth lumbar dermatome and some motor function was retained in the lower extremities through-

out the operative period. The larger doses of pontocaine in hypobaric solution (6 to 8 cc.) raised the level of anesthesia by one or two dermatomes. However, a change in the position of the patient resulted in a marked change in the level of anesthesia

TABLE IV DURATION OF ANESTHESIA	
Minutes	No. of Patients
90	6
120	20
150	15
180	25
210	4
240 or more	5
Total	75

and warrants a word of warning. The patient should be definitely and repeatedly admonished not to raise his head or shoulders until at least twenty minutes after the administration of the anesthetic solution. On two occasions patients failed to adhere to this caution and raised their heads and shoulders off the table for a short period of time. The level of anesthesia ascended rapidly into the mid-dorsal region. On two other occasions the level of anesthesia appeared to be too low for the excision of extensive pilonidal cysts but ascended into the upper thoracic region when the patients' heads were raised for short periods of time.

The duration of anesthesia (Table iv) averaged two or more hours. Occasionally anesthesia of sufficient intensity to permit an operative procedure was still present four hours after the administration of the hypobaric solution. A definite correlation could be established in many instances between a given dose of pontocaine and the duration of anesthesia, namely, 6 mg. of pontocaine produced anesthesia lasting from two and a half to three hours whereas 4 mg. of pontocaine produced anesthesia lasting only from one and a half to two hours.

There were five instances in which it was necessary to abandon the procedure as described and utilize some other method of anesthesia. In four such instances it proved

to be impossible to perform lumbar puncture in the prone-flexed position; this undoubtedly was due to the anesthetist's inexperience with the technic. The fifth failure occurred in a twenty-six year old, male negro who was scheduled for a re-excision of condylomata acuminata of the anal region and in whom the original excision had been successfully performed under spinal anesthesia administered in the prone-flexed position. Lumbar puncture was again successfully performed in the prone-flexed position; however, the surgical service requested a 10 cc. sample of cerebrospinal fluid for analysis and it proved to be impossible to obtain this large an amount. The patient was therefore turned to the lateral decubitus position, a second lumbar puncture as performed, the necessary cerebrospinal fluid was obtained and the spinal anesthetic was then administered.

Certain complications arose during the course of operation and were attributed to the anesthetic method. There were eight instances in which the patient, during the course of hemorrhoidectomy, complained of a dull, aching, abdominal pain often limited to the suprapubic region but occasionally referred to the epigastrium. This pain occurred simultaneously with over-dilatation of the rectum and promptly disappeared when such dilatation was discontinued. This was undoubtedly referred pain travelling through visceral afferent fibers of the sympathetic nervous system to the hypogastric and aortic plexuses. In only one instance was it necessary to administer supplementary anesthesia; all the other patients described the sensation as being annoying rather than truly painful. In three instances the level of anesthesia was inadequate for the extent of the operation contemplated and supplementary intravenous anesthesia was necessary; these three patients had extensive pilonidal sinus tracts. Nausea, sweating and dizziness were noted in five patients and seemed to be correlated with extreme apprehension and emotional instability.

The postoperative complications noted during the period of hospitalization (Table v) were of three types, urinary retention, postspinal headache and discomfort at the site of lumbar puncture. Eleven patients required catheterization but none of these

TABLE V  
INCIDENCE OF POSTOPERATIVE COMPLICATIONS

Complication	No. of Instances
Catheterization.....	11
Difficulty in voiding.....	4
Severe postspinal headache.....	6
Mild postspinal headache.....	4
Low back discomfort in relation to site of lumbar tap.....	3

required it on more than one occasion. Four other patients experienced difficulty in voiding but did not need to be catheterized. Four patients suffered typical and severe postspinal headaches. Six other patients complained of mild headaches that were neither incapacitating nor typical. Moderately severe low back pain in relation to the site of lumbar puncture occurred in two instances but in only one was this pain correlated with any difficulty in performing lumbar puncture.

#### COMMENTS

One disadvantage encountered with the technic was that of postspinal headache. However, this complication was not foreign to other types of spinal anesthesia; and although this series was limited numerically, the incidence did not appear to be abnormally high. A second disadvantage common to surgical procedures on the anorectal region under any form of anesthesia was a definite incidence of postoperative urinary retention. Whether this complication was due to the anesthesia *per se* or due to the reflex effect produced by the surgical procedure on the autonomic nervous system, was a moot question. A third disadvantage was the reflex abdominal pain when the surgical procedure involved over-dilatation of the rectum. The limitation of the extent of anesthesia, one of the method's major advantages, became a disadvantage under certain circumstances.



The level of anesthesia proved to be too limited for some surgical procedures involving extensive pilonidal sinus tracts. A fifth disadvantage was the position utilized in the performance of this technic, a position which was definitely contraindicated in patients with decreased vital capacity due to poor cardiac reserve, chronic pulmonary disease or other conditions impairing pulmonary ventilation.<sup>9</sup>

One of the outstanding advantages of the technic and a source of great appeal to both the anesthetist and the surgeon working on a busy surgical service was the rapidity with which anesthesia could be induced and operation begun. Ability to perform lumbar puncture in the prone-flexed position was easily acquired by a competent anesthetist. The onset of analgesia was prompt and as the patient was already in the optimal position, operation could be undertaken immediately. A second advantage was the prolonged anesthesia that was obtained at the expense of a minimal amount of anesthetic agent. A third advantage was the definite limitation in the extent of anesthesia which ensured the absence of circulatory depression and, since motor power to the lower extremities usually remained intact, permitted immediate ambulation upon completion of the surgical procedure thereby minimizing postoperative vascular and respiratory complications.

#### SUMMARY

1. Spinal anesthesia utilizing pontocaine in hypobaric solution and administered in the prone-flexed position, is redescribed.
2. This technic was successfully employed in seventy-five instances of surgical procedures involving the anorectal region; in five other instances failures occurred.
3. Complications arising from the use of this type of anesthesia included urinary retention, postspinal headache and discomfort at the site of lumbar puncture.
4. The advantages and disadvantages of the technic are weighed.

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# pHISODERM WITH HEXACHLOROPHENE (G-11)\*

## ITS INTEGRITY AS A SURGICAL SCRUB

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MODERN labor and time-saving devices have stimulated efforts to promote efficiency in all phases of life most particularly in the manpower-saving aspects. The apparent wastefulness of the ten- to twelve-minute soap scrub is detrimentally reflected in the pattern of efficiency in surgical operating room work where delay in any one section of individuals contributing to that work magnifies the lost time as other members of the staff are reduced to idleness. The time factor became extremely important when rigid forty-hour schedules were introduced for all workers except physicians and the destruction of time produced serious economic losses. Realizing that time applied for the benefit of the patient during operations must in no respect be compromised if that time is necessary to obtain sound surgical results, attention must be directed to those time-saving factors which will allow streamlining and at the same time not be deleterious in any manner to the patient's successful surgical progress. The lengthy soap scrub technic is therefore subject to scrutiny and is a candidate for revision.

Previous to the introduction of detergents all methods required ten to twelve minutes of time per individual besides the labor of preparing soap solutions, brushes, containers, basins and antiseptics. Occasional skin reactions prohibited a certain number of operating room personnel from participating in surgical action, often intermittently and rarely permanently. Also, the irritated skins of some participants are questioned from a technical

viewpoint due to the fact that bacteria are numerous demonstrated in such skin areas and are therefore dangerous.

Therefore, it appears proper to establish the efficacy of a detergent which will cleanse, lower the bacterial count of the skin, reduce skin irritability, save time and not increase the incidence of wound infection.

pHisoderm plus G-11 (3 per cent)\* has been extensively studied in the laboratory and found to meet all of these criteria.<sup>1-10</sup> Several institutions have used this detergent and the staff members are enthusiastic about its safety. Some have used the brush, some have prepared the patient's skin with the detergent, but all have reduced their scrubbing time to three to four minutes.

When experimental evidence was sufficient to predict safety, it occurred to us that the time had arrived for clinical testing; and at Kennedy Veterans Administration Hospital we set up a protocol which appears to be the most rigorous and demanding of all previously reported tests.

### PROTOCOL

All features of the surgical management of the patient have remained the same except the actual scrubbing technic of the operating team. The patient's skin is prepared by the usual shave, soap, water, ether, alcohol and merthiolate technic. Antibiotics and other chemotherapeutic agents have been employed with the same frequency and dosage as before the experi-

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ment. The same criteria demanded of the condition of the preoperative skin were employed. The only change introduced was the scrubbing technic of the team.

Since July 14, 1948, all operations performed by general surgery, orthopedics, thoracic surgery, urology and neurosurgery were included in the experiment until 1,500 clean cases had been tested.

All wounds have been carefully observed and studied bacteriologically if any degree of infection existed. The report includes all stitch abscesses and gross wound infections. It does not include observations of results obtained by swab cultures around apparently healthy wounds. It is the author's opinion that the demonstration of live bacteria in a clinically non-infected wound is not significant because there has been no interference with healing and no early or late infectious complications.

The observations are made in wounds classified according to ordinary operating room parlance, namely, clean, potentially dirty or dirty. Freeman and Young<sup>11</sup> have used contaminated and infected wounds for the potentially dirty and dirty cases, respectively.

All reddened, indurated areas and seromas and hematomas were cultured. If the cultures were not positive and no subsequent breakdown or stitch abscess occurred, the result was classified as not infected. Mild puffiness or cellulitis appearances are not classified as infected unless subsequent breakdown, abscess or stitch abscess appeared.

*Expectant Prescrub State.* All scrubbing personnel are requested to maintain clipped fingernails and to exercise normal home cleansing procedures at all times. This request existed for years prior to the start of this experiment.

*Scrubbing Technic.* Wash hands and arms with pHisoderm and G-11 and water for one minute. Two pushes on container plunger will evict enough material for this purpose (approximately 2 cc.). Rinse with water then cleanse nails with orange stick. Wash hands and arms with same material

and water for two minutes then rinse with water. No brushes, no antiseptic washing or soaking are necessary. Actual scrubbing time is four minutes.

*Explanation of Clean, Potentially Dirty and Dirty.* All operations in which *per*

TABLE I  
INFECTIONS

Number	Clean	Poten- tially Dirty	Total
Operations.....	1,500	430	1,930
Infections.....	24	17	41
Percentage of infections.....	1.6	3.95	2.12

*primam* healing is expected are considered clean. All operations are considered potentially dirty in which *per primam* healing may be accomplished but in which the likelihood of infection is possible because of varying degrees of contamination. Those conditions considered dirty are those not closed at operation in which *per primam* healing is impossible due to extensive gross infection.

ANALYSIS OF RESULTS

During the period of experiment 2,416 operations were performed. There were 1,500 classified as clean, 430 potentially dirty and 486 dirty cases. Obviously all of the dirty operations healed by secondary intention as all were infected. Table I contains the results in the cases in which *per primam* healing was expected. An analysis of the infected cases is illustrated in Tables II and III.

COMMENTS

Obviously, defective scrubbing technic is not responsible for all infections; technical errors at the table are responsible for some. For instance, two of the hernioplasty infections were extensive procedures which required scrotal as well as inguinal work; definite breaks were observed. The mild infections seen in removal of ulcerated carcinomas of the face and ear may be due to existing infection in the open lesions.

The two positive cultures in the neuro-surgical cases without obvious superficial or deep infection might be errors in the collection of the specimens or in the laboratory. The late infection in the hemispherectomy followed numerous aspirations

table errors are admitted. Also, the results are tabulated from the work of the inexperienced junior resident as well as the experienced senior residents and section chiefs. It is a matter of common knowledge that the experienced operators or teams

TABLE II  
INFECTIONS IN CLEAN CASES

Name	Operation	Type	Severity	Organism
M. E.	Craniotomy	Gross	Severe	Hemolytic Staph. aureus
J. S.	Hernioplasty	Stitch	Minimal	Not obtained
J. H.	Hernioplasty	Stitch	Moderate	Not obtained
O. T.	Excision keloids	Stitch	Minimal	Not obtained
L. D.	Carcinoma ear, with skin graft	Stitch	Slight	Not obtained
R. R.	Craniotomy	Late skin infection	Mild	Hemolytic Staph. aureus; P. aeruginosa
O. C.	Hemispherectomy	Gross	Severe	Hemolytic Staph. aureus
B. P.	Tractotomy	Gross	Mild	Hemolytic Staph. aureus
C. B.	Exploratory laparotomy	Stitch	Slight	Staph. aureus
A. McK.	Gastrectomy	Gross	Moderate	Hemolytic Staph. aureus
D. M.	Hernioplasty	Gross	Moderate	B. coli
L. R.	Craniotomy	Gross	Moderate	Hemolytic Staph. aureus
W. L.	Craniotomy	Gross	Severe	A. aerogenes
W. M.	Superficial femoral vein ligation, bilateral	Gross	Moderate	Hemolytic Staph. aureus
K. S.	Burrholes	No clinical infection	.....	A. aerogenes
S. S.	Cranioplasty	No clinical infection	.....	Hemolytic Staph. aureus
H. H.	Cholecystectomy and appendectomy	Partial	Mild	Hemolytic Staph. aureus
R. B.	Plastic flap	Stitch	Mild	Hemolytic Staph. aureus; P. aeruginosa
M. C.	Spine fusion	Stitch	Mild	Hemolytic Staph. aureus
C. O.	Appendectomy	Gross	Moderate	Hemolytic Staph. aureus
A. J.	Gastrojejunostomy; appendectomy	Gross	Moderate	Hemolytic Staph.
H. C.	Open reduction tibia	Stitch	Single	Sterile
A. M.	B/K amputation	Gross	Severe	B. welchii
M. M.	Excision carcinoma face, and graft	Gross	Mild	Not obtained

of the subflap space. One can continue to a point of excising a great number of these infections from the responsibility of the scrubbing technic. However, technical errors exist as a factor in all wound infections and are so indefinite in their degree of harm that we have discarded them as such. For the purpose of this experiment all infected wounds are included as an indictment of guilt for the scrubbing technic.

Comparative figures are of little value but it appears that any technic which limits the number of infections to 1 to 2 per cent in clean cases cannot be condemned as unsafe. A certain number of technical

will work with a lesser number of resulting infected wounds. The results of surgery in the septic age clearly demonstrated this point. It also seems logical to assume that the scrubbing technic is sound if a large number of potentially dirty cases can be performed with an infected rate no higher than 3.95 per cent. Statisticians may require a larger series of cases than we have reported to establish the integrity of this scrubbing technic. But enough experience has been gained by this study so that not a single surgeon employing this technic has expressed apprehension although many were skeptical when the

experiment was launched. No surgeon was commanded to continue this technic if he deemed it unsafe yet no surgeon has returned to the old ten-minute soap scrub.

The technic simplifies the chores of nurses, attendants and physicians. Nurses

feel secure that his hands and arms are properly prepared.

It is not possible at this time to comment upon economy. Soap, brushes, containers, alcohol or other antiseptic soaks are items which cost money; pHisoderm and G-11

TABLE III  
INFECTIONS IN POTENTIALLY DIRTY CASES

Name	Operation	Type	Severity	Organism
C. L.	Gastrectomy and colon resection	Gross	Severe	<i>B. coli</i>
G. P.	Syme's revision amputation stump	Gross	Moderate	Hemolytic <i>Staph. aureus</i>
B. R.	Choledochojejunostomy	Gross	Severe	<i>B. coli</i>
P. M.	Retropubic prostatectomy	Gross	Moderate	<i>B. proteus</i> ; <i>P. aeruginosa</i> ; gamma str.
S. B.	Débridement; femoral artery injury	Gross	Severe	Alpha str.; <i>B. proteus</i> ; <i>A. aerogenes</i> ; <i>E. coli</i> ; <i>P. aeruginosa</i>
J. C.	Abdominal evisceration	Stitch	Mild	Not obtained
C. R.	Skin graft, burn, leg	Gross	Mild	Hemolytic <i>Staph. aureus</i> ; Beta hemolytic str.
W. H.	Ureter, plastic	Stitch	Mild	Hemolytic <i>Staph. aureus</i>
R. P.	Hemipelvectomy	Partial	Moderate	<i>A. aerogenes</i> ; <i>Staph. aureus</i> ; alpha str.
J. DiM.	Hernioplasty and orchidectomy	Gross	Moderate	Hemolytic <i>Staph. aureus</i>
D. M.	Exploratory laparotomy; gastrotomy	Gross	Severe	Gamma Str.; <i>Staph. aureus</i>
K. B.	Colectomy	Gross	Severe	Alpha str.; <i>Staph. aureus</i> ; coliform intermediate; <i>P. aeruginosa</i>
M. T.	Pilonidal sinus	Gross	Moderate	<i>Staph. aureus</i>
G. W.	Perforated ulcer	Gross	Severe	Beta hemolytic and gamma str.; <i>Staph. aureus</i> ; <i>A. aerogenes</i> and <i>P. aeruginosa</i> ; <i>Cl. welchii</i>
G. S.	Colostomy	Partial	Mild	<i>B. coli</i>
F. McK.	Perforated ulcer	Stitch	Mild	<i>Staph. aureus</i>
F. G.	Lacerations thigh and calf	Slough of wound	Mild	Sterile

working on a forty-hour-weekly schedule are sorely pressed to prepare materials for the next day's activities. The preparation of sterile materials for the old soap technic required time and effort far above the demands of this simpler technic. The scrub room is tidied and supplied by the attendants with greater dispatch. The physicians' time is saved for more important functions. One of the practical features exists when the supervisory surgeon is called to lend a hand to an inexperienced surgeon. The supervisor can enter the operation without loss of a great amount of time. This phase was of inestimable value in a few instances of extreme emergency. It is possible for the supervisor to be ready for action in a period of three to four minutes and he can

and the dispensers also will require money. We know that approximately 10 gallons of alcohol weekly, a great amount of soap solution and brushes are not needed for this scrubbing technic in our surgical suite. It is theoretically possible for 1,000 individual scrubs to be accomplished from 1 gallon of this semiliquid material. We have learned that the figure is approximately 900 individual scrubs per gallon as there is bound to be some wasting of the material.

No team member has experienced any skin reaction and over 100 different nurses and physicians have participated in this experiment. None of the scrubbing personnel had been known to have suffered significant skin reactions during the old soap method so we are unable to cite

examples of favorable disappearance of skin disturbances by the use of this technic. However, the non-irritability of the skin suggests that avoidance of skin difficulties may be possible with the use of this method.

We have purposely avoided preparation of the patients' skin with this material in order that the scrubbing technic itself could be singly tested. It may eventually prove practical to include this as more evidence of efficacy of the material accumulates.

#### CONCLUSION

pHisoderm plus hexachlorophene (G-11) 3 per cent has been used as a four-minute, brushless scrub technic in 1,500 clean cases with a wound infection rate of 1.6 per cent and in 430 potentially dirty cases with an infection rate of 3.95 per cent. The results so far suggest that this method is as safe as any previously described scrubbing method. Numerous advantages of the method are briefly discussed.

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# A TRANSACROMIAL INCISION FOR EXPOSURE OF THE SHOULDER JOINT\*

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THE transacromial incision herein described gives excellent exposure of the shoulder joint. Hence it facilitates operations in this region, particularly those for repair of supraspinatus tendon tears or other ruptures of the tendinous shoulder cuff.

## TECHNIC

The skin incision (Fig. 1) begins 2 inches proximal to the distal end of the clavicle (acromioclavicular joint). It continues parallel and posterior to the clavicle, extends over the acromion and ends approximately 1 inch distal to the outer border of the acromion which reaches its maximum width at this point. There is practically no soft tissue between the acromion and the overlying skin.

A knife cut is made through the periosteum in the same direction as the skin incision. This is done to outline the position of the chisel used for the following step, severing the acromion. The chisel used for the osteotomy should be sharp and approximately as wide as the bone.

When the osteotomy has been completed, the severed bones are separated with a strong, self-retaining, sharp-toothed retractor. (Fig. 2.) The fragments are then separated further by hand pressure on the open retractor arms. The exploratory opening is thus widened and a full view of the entire shoulder joint is afforded. Moderate rotation of the patient's arm brings the entire tendinous cuff into sight. Splitting of the deltoid fibers a short distance downward provides ample room for repair of torn tendinous structures. If necessary, the distal portion of the acromial lip may also be removed.

When the operation is completed and the self-retaining retractors are removed, the severed bone fragments close with little pressure. Two or three sutures through the periosteum are sufficient to bring the bone edges into approximation. (Fig. 3.)

## COMMENT

Repair of shoulder joint abnormalities through the transacromial incision has given me gratifying results for a number of years. Study of the available literature did not show a procedure similar to the one described here although a number of operative approaches to the shoulder region are on record.

Codman<sup>2</sup> first reported operative intervention for rupture of the supraspinatus tendon as early as 1911. In his interesting, unusual book<sup>3</sup> he mentioned the saber-cut incision. As is well known, this descriptive term represents an anteroposterior cut over the top of the shoulder through the acromion at the acromioclavicular junction.

Codman, however, soon discarded the saber-cut incision for a much simpler one which he called the anterior incision. This extended downward from the anterior acromial edge for a distance of less than 2 inches. The anterior incision permitted (1) fair vision of the underlying bursa and tendinous cuff after separation of the "herring-bone" fibers of the deltoid muscle and (2) visualization of the humeral head following rotation of the humerus. Nevertheless, the anterior incision sometimes made it difficult to repair tendon tears.

In an attempt to correct the disadvantages of the saber-cut incision and the anterior incision a large number of other

\* Read at the North Pacific Orthopedic Society meeting October 11, 1947, Portland, Ore.

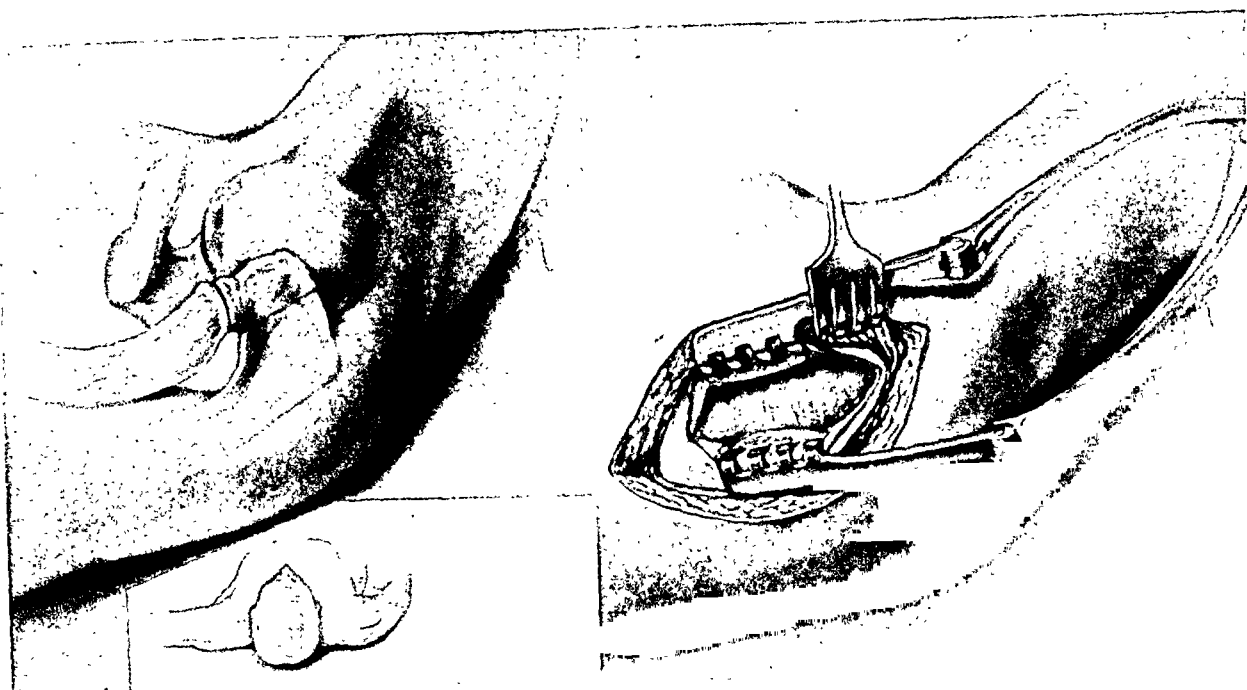


FIG. 1. Site of acromial osteotomy; skin incision is shown in inset.

FIG. 2. Manner of retracting severed acromion; bursa is visible in wound.

procedures were developed. But, according to McLaughlin,<sup>5</sup> the commonly used approaches to the shoulder joint region are practically always accompanied by one or more of the following handicaps:

(1) inadequate exposure due to obstruction by an intact acromion; (2) a poor cosmetic result due to spreading of a vertical scar; and (3) paralysis and wasting in the anterior portion of the deltoid due to operative interference with axillary nerve branches.

McLaughlin presented a superior procedure based primarily on the saber-cut incision and the posterior approach described by Kocher.<sup>4</sup> In McLaughlin's method, however, the acromion is severed in an anteroposterior direction about midway between the acromioclavicular joint and the lateral border of the acromion. The outer border of the acromion is usually discarded in this procedure; but when it is retained, closure may be accomplished by the use of soft tissue sutures. McLaughlin advised against any attempt at bone suture and said, in his experience union had always taken place without suture of the bone.

Bosworth,<sup>1</sup> whose outstanding contributions to shoulder operations are well known, in 1940 presented twenty-eight cases of incapacitating shoulder lesions which he had radically explored and repaired. Using an inverted L incision he cut the deltoid muscle from its acromioclavicular attachment and retracted backward all of the severed muscle. Bosworth was of the opinion that this division of the deltoid fibers left no permanent clinical defect.

Nicola<sup>6</sup> listed several methods for exposure of the shoulder joint. Among these were the anterior curved approach, which may be enlarged by cutting the deltoid muscle at its origin along the clavicle, and the lateral approach, which begins at the tip of the acromion and extends downward for 2 inches. If the deltoid muscle should be incised more than 2 inches from the tip of the acromion, the anterior circumflex vessels and the anterior branch of the axillary nerve might be injured, Nicola warned.

Nicola also mentioned the anterosuperior posterior incision, extending backward along the edge of the acromion, and the curved anterosuperior posterior approach,



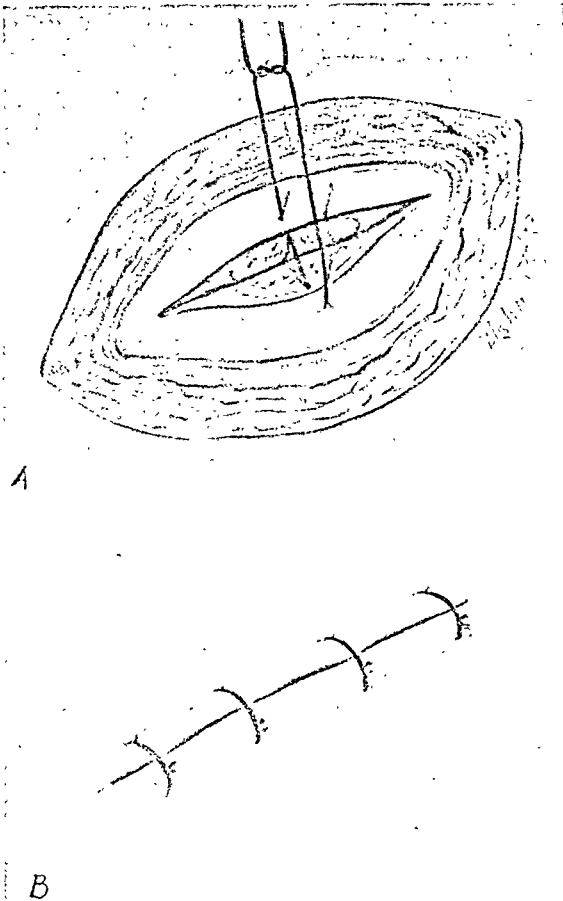


FIG. 3. A, closure of acromion by means of interrupted sutures through the periosteum; B, skin closure.

or Codman's saber-cut. According to Nicola the saber-cut procedure apparently may include severance of a portion or all of the acromial process and may or may not include disarticulation at the acromioclavicular joint.

In my experience repair through the saber-cut incision was frequently followed by non-union of the severed acromion.

This was distressing as the severed acromion was clearly visible in roentgenograms. Although the ununited acromion probably caused little disability, the patient, seeing his roentgenogram, often could not escape a feeling of insecurity regarding the results of the operation. Repair through the transacromial incision insures approximation of the severed acromion and subsequent roentgenograms show no bone abnormality.

#### SUMMARY

1. A simple transacromial operative procedure for exposure of the shoulder joint is presented.
2. Use of this procedure over a number of years proves: it insures adequate exposure of the shoulder joint so that repair of torn tendons is easily carried out; it is safe because no harm can be done to the vessels and nerves of the deltoid muscle; and it gives an excellent cosmetic result.

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# THE OXYHEMOGRAPH\*

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THE feasibility of using the photoelectric method clinically for determining and continuously recording the oxygen saturation of blood during anesthesia by means of a portable sensitive apparatus was reported by the authors for the first time to the American Surgical Association in 1940.<sup>1</sup> Since that time we have devoted our efforts largely to the development and proving of a portable, stable and reliable amplification and control system that might be used with various types of photocell applicators.

In our work on oxyhemography the chief difficulty encountered has been in instability and inconsistencies seemingly inherent in amplifiers of the conventional D.C. type. Several of our earlier models incorporated these conventional D.C. amplifiers and, although sensitive, were found to be too unreliable for prolonged experimental or clinical application. We were particularly fortunate in obtaining midway in our studies a "contact modulated D.C. amplifier" through Mr. C. F. Kettering which is both stable and sensitive. Further adaptation and the necessary controls were worked out through the collaboration of Mr. F. W. Chapman<sup>2</sup> of the General Motors Research Laboratories.

With the amplifier<sup>3</sup> in its present form the signal from the photocell applicator is converted by the motor driven input breaker to pulsating current of 80 cycles per minute. This 80-cycle current signal is now amplified approximately one million times with the usual resistance-coupled alternating current amplifier. The amplified signal is now rectified by an output breaker to produce an unidirectional output current adequate to operate the ink-writing recording milliammeter. This procedure of ampli-

fying the input signal only after it has been converted to alternating current eliminated the greatest factor of instability in the direct coupled D.C. amplifiers caused by variations in the tube electron streams. Such variations are apt to be large in comparison with the input signal and be insignificant in the amplification factor of the tubes. The contact modulated amplifier avoids this source of instability because the operation is effected by the dynamic amplification factor of the tubes. A second distinct advantage is the breaker system since synchronous rectification in the output circuit allows only those voltages of the same frequency as the input breaker to produce a direct current component in the output circuit. Extraneous fields from other electrical equipment unless identical with the breaker frequency will produce only alternating current components in the output circuit and will not actuate the D.C. recorder.

The operation of the photocell unit depends upon the fact that in the red region of the spectrum reduced hemoglobin absorbs more light than oxyhemoglobin; therefore, when the unit is applied to the tissues, a variation in the red light absorption indicates a change in relative amounts of oxygenated and reduced hemoglobin under observation. Many types of photocell applicators have been devised and may be either of the high-vacuum emissive phototube or the barrier-layer type. We have built and used three of the former type<sup>1</sup> but find the latter type superior largely because the small size and light weight adapts it to use on the ear.

Nicolai<sup>4</sup> was apparently the first to determine oxyhemoglobin photoelectrically but Millikan<sup>5</sup> devised and described a two-

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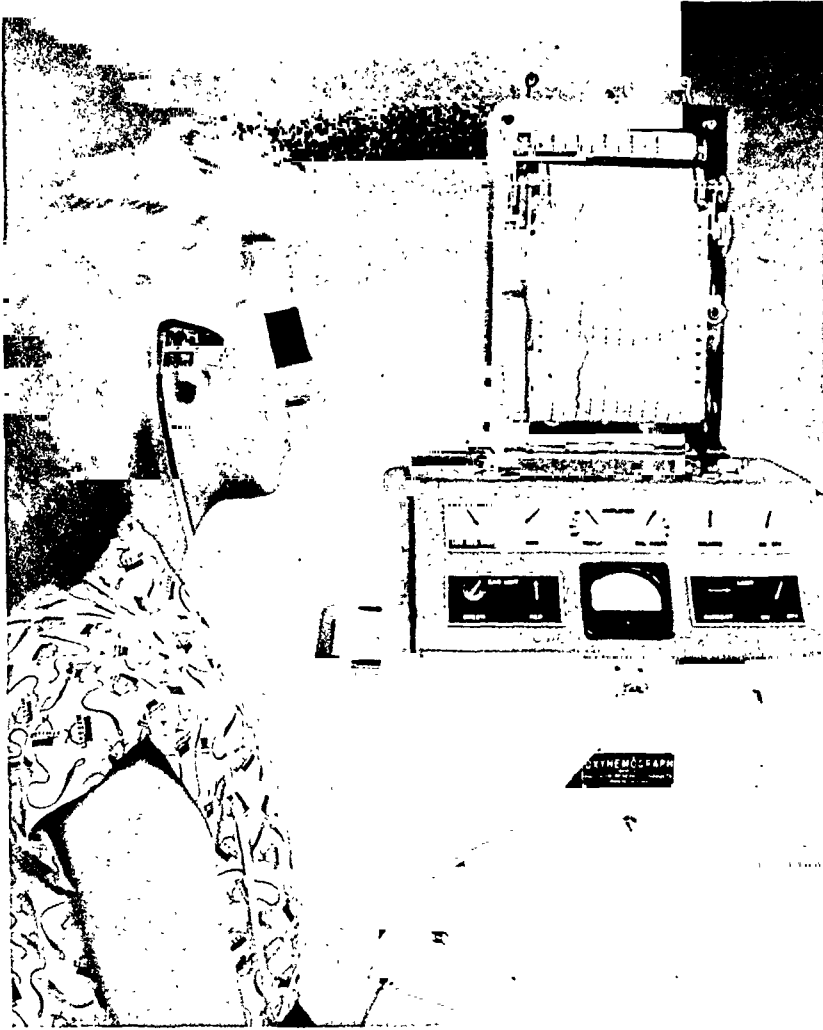


FIG. 1. The new model oxyhemograph in operation.

color colorimeter a year later. Kramer<sup>6</sup> and Matthes<sup>7</sup> applied the photoelectric method to oxyhemoglobin in tissues in 1934 and 1935 but "volume variables," particularly vasomotor changes resulting from blood pressure fluctuations, were not fully considered until Goldie with his ratiometer and Hemingway and Taylor through their automatic compensation suggested by Millikan<sup>8</sup> attempted to eliminate them as sources of error. Other efforts to correct "volume variables" involve a second spectral region sensitive to total hemoglobin that is near infra red (Squire),<sup>9</sup> blue (Goldie)<sup>10</sup> and green (Matthes<sup>7</sup> and Millikan).<sup>8</sup> There is still controversy as to which method of correction is superior but we have used the Millikan-Rawson cell for the

most part. The new model oxyhemograph\* (Fig. 1) is so arranged that photocells incorporating either the green or near infra red as the second spectral region may be used.

#### SUMMARY

A photoelectric apparatus (oxyhemograph)<sup>3</sup> is described which detects anoxemia in early stages not detectable by any other method due to the fact that any change in the light absorption of the hemoglobin produces a signal from the photocell which appears as a recording after a million times' amplification.

The possible applications of this instru-

\* Manufactured by Photocon Research Products, 1062 North Allen Avenue, Pasadena 7, California.

ment to physiology and clinical medicine are obviously numerous but we have used it to date principally in the experimental and clinical study of anesthesia, congenital malformations of the heart and cardio-respiratory insufficiencies.

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# INTRAMUSCULAR INFUSIONS OF PROTEIN HYDROLYSATE\*

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PARENTERAL fluids may be given by the intravenous, subcutaneous, intramuscular, intrasternal and intraperitoneal routes. The intravenous and subcutaneous paths are used most frequently for the infusion of large quantities of isotonic solutions. Little attention is given the intraperitoneal system for adults in this country whereas in the infant this site is employed rather frequently. The intrasternal passage is reserved chiefly for the administration of blood and plasma when the intravenous system is not readily available.

Muscles have long been the path of choice for the injection of small quantities (1 to 10 cc.) of medicaments because of simplicity of injection, the rapidity of absorption and the minimal number of symptoms related to the procedure. Crystalloids, plasma and serum are frequently injected intramuscularly in infants. During the course of the investigation of liquid isosmotic plasma and serum the intramuscular system was found to be a ready route for the infusion of this agent as an adjunctive pathway in the management of shock or for the correction of hypoproteinemia and dehydration.<sup>1</sup>

The protein hydrolysate solution† used in this investigation is a commercially available product prepared from bovine plasma. This preparation has been described in previous reports.<sup>2</sup>

To maintain daily positive nitrogen balance postoperatively by total parenteral alimentation, it is necessary to give 2, 3 or 4,000 cc. of 5 per cent protein hydrolysate

solution in the average major surgical procedure.<sup>3</sup> One and a half hours are usually required for the intravenous administration of 1,000 cc. of this protein hydrolysate solution,<sup>4</sup> hence, four to six hours are required for total intravenous alimentation in a twenty-four-hour period. If the intravenous infusion takes three or four hours per 1,000 cc., the patient may be immobilized for as long as twelve hours for total parenteral therapy. The patient, therefore, is in bed the greater part of the day and ambulation is delayed. Likewise, the restricted activity of the arm during intravenous infusions increases the patient's postoperative discomforts. Other handicaps to the use of the intravenous path are the difficulties associated with repeated venipuncture.

We have employed the subfascia lata space and the lateral muscles of the thigh as a route for the rapid infusion of 1,000 cc. of 5 per cent protein hydrolysate solution.<sup>2</sup> The average rate of injection by gravity with this method is 30 to 35 cc. per minute. At this rate 1,000 cc. may be injected in approximately thirty minutes.

Two hundred fifty-four rapid intramuscular infusions into the vastus lateralis muscle of the thighs have been employed in 112 patients without local reactions, irritations or failure of absorption.

Finley and his associates<sup>5</sup> have practiced subfascia lata infusions of 1,000 cc. of isotonic sodium chloride or 5 per cent dextrose solutions. Their report reveals that the average time for delivery of the solution by this route is fifty-six minutes whereas in thirty-three consecutive cases of subcutaneous infusions 167 minutes were

† Supplied by Baxter Laboratories, Inc., Morton Grove, Ill.

\* From the Department of Surgery of the George Washington University School of Medicine and the Surgical Department of the Gallinger Municipal Hospital, Washington, D. C.

required for successful injections. One of the early writings on the intramuscular path for the injection of dextrose was that of Nassau in 1926.<sup>6</sup> During the next years only a few reports of the intramuscular injection of dextrose in infants and children appeared in this country and in Germany.<sup>7-10</sup> In 1939 Horsley<sup>11</sup> described the muscular route to be an efficient and simple method for administering dextrose and Ringer's solution.

#### TECHNIC OF INFUSION

A Y set-up is used for the simultaneous administration of a 5 per cent protein hydrolysate solution to each leg. The bottle of solution is suspended 3 feet above the level of the thigh. Two 15-18 gauge, 2½ inch, long beveled needles are employed. Air is removed from the infusion system by filling the tubes with solution after which the shut-off clamps are closed. The site selected for the injection is the lateral side of the thigh at a point midway between the anterior and posterior surfaces at the junction of the upper and middle thirds. A wheal is made in the skin with 1 per cent novocain at the point of insertion of the needle. Then 5 cc. of novocain are injected into the subcutaneous tissues below the wheal. Fifty cc. of 1 per cent novocain may be placed in the hydrolysate solution to decrease some of the local discomfort. The legs are elevated slightly and are somewhat flexed at the knees so as to relax partially the iliotibial band of the fascia lata. This is best accomplished by placing a pillow under each knee. The needle is held at a 45 degree angle with the long axis of the thigh; the point is directed cephalad and the bevel outward. A sharp, firm thrust at this point puts the needle through the skin and subcutaneous fat. When the needle reaches the iliotibial band, resistance is encountered. An extra thrust is required for penetration through this layer. A sense of "give" is felt when the needle pierces the fascia lata. At this point the hub of the needle is lowered to a 15 degree angle with the long axis of the thigh and is

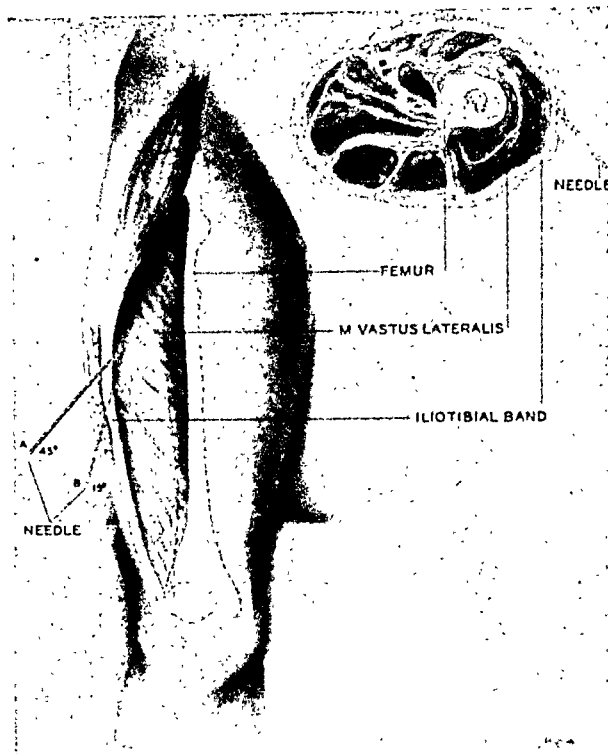


FIG. 1. Shows diagrammatically the method of inserting the needle for intramuscular infusions beneath the fascia lata of the thigh.

advanced for a distance of 1 inch into the substance of the vastus lateralis. It is important to keep the needle at a safe distance from the femur for if the periosteum of the bone is touched by the needle, the patient experiences considerable pain. In the event that the latter occurs inadvertently, it may be used as a guide for the withdrawal of the needle to the selected and correct point in the substance of the muscle. The needle is not taped to the skin because the fascia lata holds it in place. The clamps on the delivery tubes are completely opened after both needles are adequately inserted, thus allowing the solution to "pour in." It is surprising to see how rapidly the first 400 cc. are administered—four to five minutes. With the rapid infusion of the first few hundred cubic centimeters the patient notices a smarting, stretching sensation and a feeling of fullness in the thighs at the site of the injection. The next 300 cc. require about eight to ten minutes. A bulging in the lateral compartment of the thigh is noted with the injection of 500 cc. The original

manifestations described before are replaced by the symptom of a heavy feeling in the legs. The last 300 cc. usually consume fifteen to twenty minutes. This slowed rate of infusion is due to the increased tension produced by the large

indicates an average rise of amino acids of 1.06 mg. per 100 cc. of plasma above normal at the end of the injection, a 1.2 mg. elevation one hour later, a sustained elevation of 0.8 mg. two hours later and a retained rise of 0.3 mg. three hours after

TABLE I  
BLOOD AMINO ACID AND UREA NITROGEN CHANGES AFTER RAPID INJECTION IN BOTH LEGS OF 1000 CC. OF PROTEIN HYDROLYSATE SOLUTION CONTAINING 50 GM. HYDROLYSATE IN THIRTY MINUTES

Constituent Analyzed	Before Injection	Half-hour-end of Injection of 1,000 cc.	One Hour Later	Two Hours Later	Three Hours Later	After Twenty-four Hours
Amino acid nitrogen.....	6.2*	7.6	7.4	7.0	6.5	6.2
mg. per 100 cc. plasma.....	5.8-6.6†	6.8-7.8	7.2-7.7	6.8-7.4	5.9-7.0	5.7-6.5
Urea nitrogen mg. N.....	12.4	12.8	12.6	12.8	11.8	12.3
per 100 cc. plasma.....	10.0-13.9†	11.0-14.0	10.5-13.6	10.8-14.2	10.9-13.0	9.6-14.2

\* Average values  
† Range of values  
Number of cases: 10  
(From WEINSTEIN, J. J. Intravenous, subcutaneous and rapid intramuscular infusions of "protein hydrolysate." *Surg., Gynec. & Obst.*, 87: 12, 1948.)

amount of solution present in the confined space of the lateral compartment of the thigh. It may be said that the rate of administration is inversely proportional to the tension in the compartment produced by the quantity of injected fluid. (Fig. 1.)

TOLERANCE AND ABSORPTION

The patients receiving protein hydrolysate intramuscularly were the postoperative surgical patients requiring parenteral fluids and protein nutrition, or the preoperative patient with a history of malnutrition, weight loss and measurable hypoproteinemia who could not take adequate amounts of protein orally (viz. pyloric obstruction, ulcerative colitis). Thus, rather ill surgical patients were used in this investigation. The largest amount of protein hydrolysate administered by the muscular path to one patient was 28,000 cc. in a fourteen-day period.

A review of the effect on blood amino acid nitrogen and urea after the intramuscular injection of 1,000 cc. of protein hydrolysate solution in thirty minutes

completion of the infusion. The urea figures do not indicate significant changes for the same periods. Table I gives the average values and the range of change in blood amino acids and blood urea for ten patients who received 1,000 cc. of protein hydrolysate solution rapidly intramuscularly. The amino acid changes expressed

TABLE II  
CHANGES IN AMINO ACIDS AS PER CENT ABOVE NORMAL AND PERCENTAGE DIFFERENCE BETWEEN EACH PERIOD AS COMPARED TO MAXIMUM LEVEL

	End of Infusion	One Hour Later	Two Hours Later	Three Hours Later
Percentage rise above normal.....	15.4*	19.3*	13.0*	4.0*
Difference in percentage change.....	15.4*	3.9*	-6.3	-8.2

\* Average values.  
Number of cases: 10.

in terms of per cent rise above normal and per cent difference for each period as compared to the maximal rise seen at the end of the injection is described in Table II.

Further evidence for the rapid absorption of protein hydrolysate given intramuscularly is observed in an analysis of the absorption and excretion rate of 1 cc. of phenolsulfonphthalein dye that is added to the 1,000 cc. solution to be injected. Analysis of this experiment shows 46 per

cent excretion of control and the average changes in leg measurements.

#### SUMMARY AND DISCUSSION

Medical and surgical patients may have a deranged protein balance because of

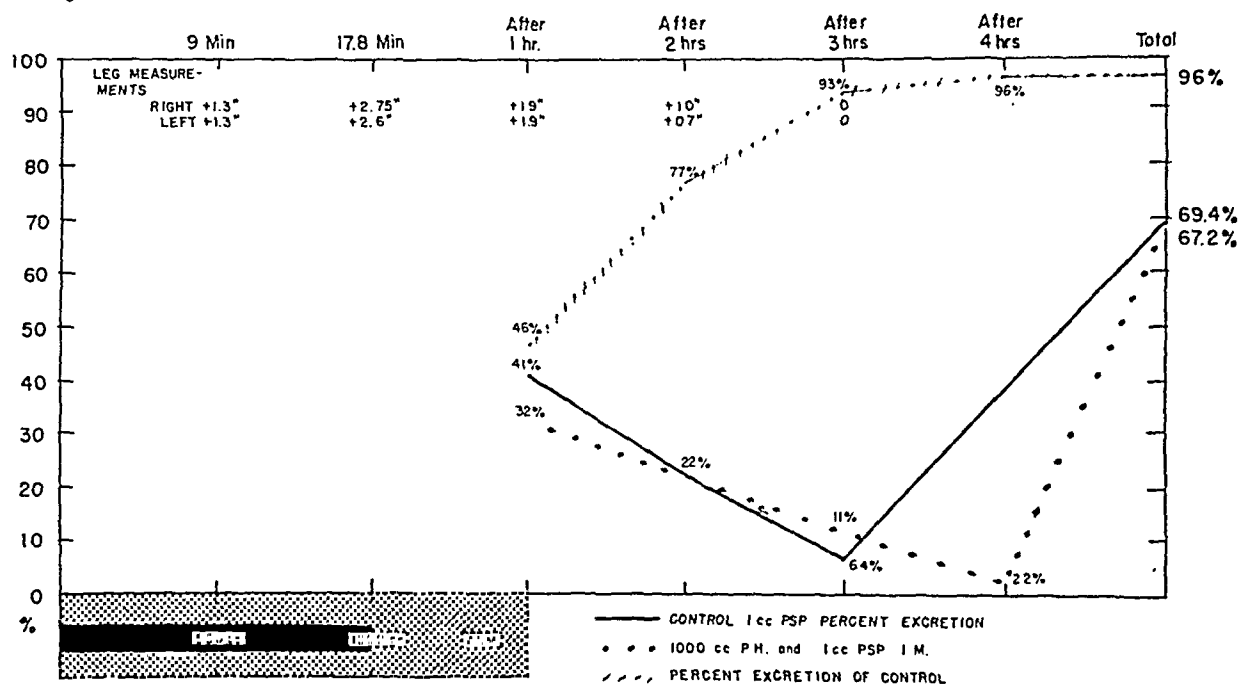


FIG. 2. Shows rapid absorption of protein hydrolysate given intramuscularly; five cases.

cent of normal absorption and excretion of the dye one hour after the end of the infusion, 77 per cent of normal absorption at the two-hour postinfusion period and 93 per cent of normal absorption and excretion of the dye in the hydrolysate three hours after the injection. A total absorption and excretion of 96 per cent of dye was found four hours following the injection.<sup>2</sup>

Leg measurements performed concomitantly with the study of phenolsulfonphthalein absorption and excretion reveal a maximum increase in diameter of the thigh at the end of the infusion (2.75 inches above preinfusion level) and a return to normal size within three hours following the injection.

Figure 2 gives the per cent excretion of phenolsulfonphthalein in the control test, the per cent excretion of the dye when 1 cc. is added to the 1,000 cc. of protein hydrolysate infused intramuscularly in

limited or inadequate intake, loss through abnormal routes, excessive catabolism, faulty digestion and absorption, and abnormal utilization and fabrication of proteins. When the oral route is available and efficient, this is certainly the path of choice for protein feeding. However, there are numerous instances wherein the oral route is not available or it may be contraindicated because of disease. Therefore, the parenteral channel must be resorted to for maintenance of daily nitrogen nutrition to help build up depleted reserves and to correct hypoproteinemia. The intravenous route is used most frequently but has its disadvantages. Some of these are as follows: accessible veins may not be available; the size of the veins may make repeated infusions impractical and difficult; trained personnel may be unavailable for efficient intravenous injections; and repeated venipunctures unless performed with extreme



care produce fibrosis and thrombosis which, in turn, limit the life of the accessible and usable veins.

A plausible technic for the administration of protein hydrolysate solutions is a method which is simple to perform, does not require great skill, insures absorption, avoids long periods of immobilization, eliminates the discomforts associated with fixation of the arm for hours and decreases the total incidence of local and general reactions. Rapid intramuscular injections of protein hydrolysate (prepared from bovine plasma) into the lateral surface of the thighs fulfill the aforementioned criteria.

Analysis of this study shows that there is maximum absorption the first two to three hours after the end of the injection in thirty minutes of 1,000 cc. of 5 per cent protein hydrolysate solution. Hence, intramuscular infusions of 1,000 cc. each may be performed and repeated every six hours with maximum safety and efficiency.

The blood amino acid levels attained after rapid intramuscular infusion of 1,000 cc. in a half hour indicate that the maximal levels reached by this route are only one-half that seen with the intravenous infusion of similar amounts in one hour. Therefore, the likelihood of systemic reaction is considerably reduced.

Many institutions are afflicted with a shortage of personnel. Hence, the intramuscular method of infusion could be safely and efficiently executed by the nursing staff so as to relieve the active internes or residents for more pressing duties. It is my opinion that a more efficient service for parenteral therapy could be maintained in hospitals by the use of a trained team of physicians or technicians rather than the usual practice of having each intern or resident on the case do the injection or transfusions. Proof of this is seen in operating rooms where the anesthesiologists are solely responsible for maintenance of fluid and blood volume during surgery. Also, throughout the years of managing a blood bank in a hospital I have seen greater efficiency in phlebotomy when

a trained group of technicians or nurses are used in preference to the floating intern or resident.

In the course of management of postoperative surgical patients it has been found necessary to give 3,000 or 4,000 cc. of protein hydrolysate solution per day to each patient for positive nitrogen balance with total parenteral alimentation. If the intravenous system is employed, at least four and a half to six hours of immobilization are required to administer this quantity. In the event of slower rates of infusion than the usual 10 to 15 cc. per minute the patient may be immobilized for twelve hours or more for the successful infusion of 3,000 cc. of fluid. This is indeed a handicap to the postoperative patient and decreases the likelihood of early ambulation and its concomitant benefits. Therefore, we have added the rapid intramuscular method of infusion to our program of postoperative parenteral nutrition. A simple program that will maintain positive nitrogen balance postoperatively in the greater number of cases is as follows: 1,000 cc. of protein hydrolysate with dextrose in the morning intravenously in one and a half hours, 1,000 cc. of protein hydrolysate, plain, intramuscularly in the afternoon in thirty minutes and 1,000 cc. of protein hydrolysate with dextrose intravenously in the evening. Thus only three and a half to four hours of the day are used for infusions and the patient is free for active motion in the remaining periods. Additional infusions may be given intramuscularly or intravenously.

Total parenteral alimentation is performed not only in surgical patients but also in medical patients with acute inflammatory lesions of the gastrointestinal tract, viz., regional ileitis, ulcerative colitis or obstructive lesions of the upper gastrointestinal tract being prepared for surgical intervention. A recent experience with a patient who was operated upon for acute appendicitis but in whom an extensive, acute regional ileitis with perforation was found, bears out the advantage of using

the intramuscular route for infusions in patients on total parenteral alimentation. Few accessible veins in the arms, hands or feet could be found in the patient; in fact the only readily available vein was the internal saphenous near the ankle. Because of the inherent technical difficulties of maintaining catheterization of a vein for continuous intravenous administration for the planned fourteen-day period, the intramuscular route was selected. One thousand cubic centimeters of protein hydrolysate were infused by the intramuscular path twice a day for fourteen days. Repeated blood studies revealed no significant drop in the total protein or albumin content during this two-week period. However, an approximate weight loss of 11 pounds was seen after ambulation.

#### CONCLUSIONS

1. A protein hydrolysate solution containing 50 Gm. of protein in 1,000 cc. of distilled water can be given intramuscularly into both thighs simultaneously at a rate of 25 to 30 cc. per minute in 1,000 cc. doses.

2. The injections are made into the lateral side of each leg simultaneously with a  $2\frac{1}{2}$  inch 15-18 gauge needle at a point midway between the anterior and posterior surface of the thigh and at the junction of the upper with the middle thirds. The needle lies well in the substance of the vastus lateralis.

3. The local discomfort associated with these infusions is minimal and no local systemic reactions have been seen in 254 consecutive injections.

4. The time required for absorption as

shown by blood amino acid levels, by leg measurements and by the excretion of phenolsulphonphthalein dye, which is used as an indicator in the solution, is three hours.

5. In view of the absorption rate with intramuscular infusions of 1,000 cc. of protein hydrolysate it is suggested that each dose of 1,000 cc. be given at six-hour intervals.

6. The intramuscular route is a safe pathway for the rapid infusion of large amounts of 5 per cent protein hydrolysate solution.

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# ETIOLOGY OF PRIMARY VARICOSE VEINS\*

## HISTOLOGIC STUDY OF ONE HUNDRED SAPHENOFEMORAL JUNCTIONS

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MUCH confusion and wide divergence of views exist in the voluminous literature on the etiology of primary varicose veins in the lower extremities. The various theories, however, can be placed in two main groups, one stressing mechanical or hemodynamic factors and the other stressing inherent structural weakness of the veins themselves. The mechanical or aggravating factors are well known but the exact nature of the hereditary defect or inherent venous weakness has remained obscure. Variations in pattern and size of the same veins and their tributaries in different individuals as well as the marked variations in valves with respect to number, position, efficacy and the intervals between them present obstacles in interpretation not easily overcome. The saphenofemoral junction was chosen for histologic study because it is a constant structure anatomically; because the valve guarding its orifice is the most constant one in the entire saphenous system; and because the great saphenous at this area is a perforator vein at a common site of retrograde blood flow in varicose states.

### MATERIAL AND METHOD

One hundred junctions were obtained at necropsy from sixty-nine consecutive cadavers. Five specimens were from three infants, four specimens from two children and ninety-one specimens from sixty-four adults. Eight specimens of the latter were obtained from six cadavers in which it was possible to make a diagnosis of varicose veins at the time of autopsy.

Each saphenofemoral junction was removed by bisecting the inguinal ligament,

retracting the overlying skin and exposing the veins *in situ* without traction. The saphenous vein was severed transversely 1 cm. below the junction; the femoral vein was cut across an equal distance above and below the junction and the entire segment was removed *in toto*. The lumen of each vein was loosely and carefully filled with absorbent cotton from below so as not to exert pressure upon the valve leaflets and the whole specimen was fixed in 10 per cent formalin. After fixation a longitudinal section was made through both the femoral and saphenous veins. One-half of the bisected junction was discarded whereas the other half was embedded in paraffin. Triplicate histologic sections were stained with hematoxylin and eosin, with Weigert's elastic tissue stain and with Weigert's elastic tissue stain using picric acid and acid fuchsin as counterstain.

### RESULTS

Of the entire group of 100 there were only sixteen patients in whom the sinus wall of the saphenous vein opposite the valve was histologically normal; there were eighty-four in whom the sinus showed a defect in the wall that is described hereafter. This defect was present in each of the specimens from cadavers with varicose veins, in each of the four specimens from the two children, in four of five specimens from the three infants and in sixty-eight specimens from adults without apparent varicosities.

In all sections the wall of the saphenous vein both above and below the sinus and valve was normal. (Figs. 1 and 2.) The tunica intima consisted of an inner lining

\* From the Samuel D. Gross Surgical Division and Clinical Laboratories of the Jefferson Medical College Hospital, Philadelphia, Pa. Presented before the Philadelphia Academy of Surgery, February 3, 1947.

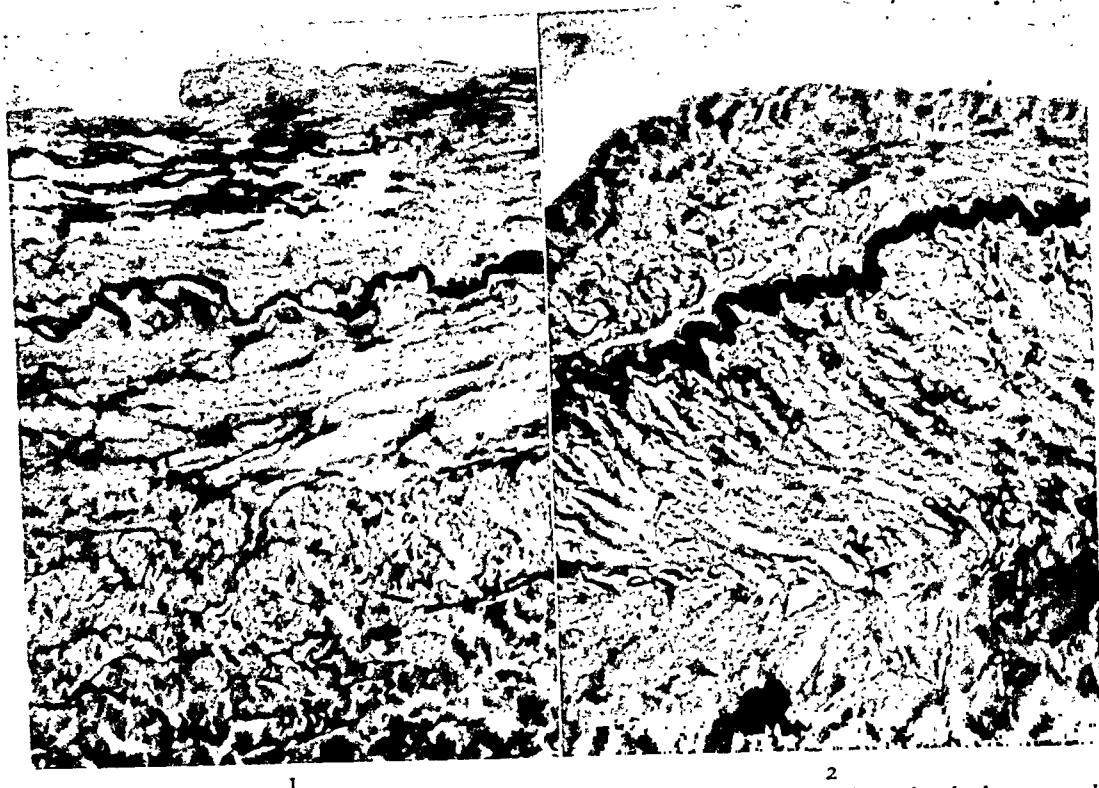


FIG. 1. Section of a normal saphenous vein above the valve showing a thick tunica intima, a well defined internal elastic membrane and a portion of the tunica media; the latter discloses numerous muscle bundles interspersed with a few collagen bundles and elastic fibers. (Elastic tissue stain  $\times 200$ .)

FIG. 2. Section of a normal saphenous vein distal to the valve showing a structure similar to that illustrated in Fig. 1. (Elastic tissue stain  $\times 200$ .)

of endothelial cells, an intermediate layer of connective tissue and an outer layer of thin elastic fibers which frequently coalesced to form a definite internal elastic membrane. The tunica media was composed of a broad layer of smooth muscle bundles between which were collagen bundles and coarse elastic fibers. The tunica adventitia was usually as thick as the media and was composed of dense acellular collagenous bundles interspersed with numerous thick elastic fibers. The valve leaflets were also normal. They consisted of a thin strand of connective tissue which was covered on its distal surface with a broad band of elastic fibers. (Figs. 3 and 4.) At the base of the valve the latter was continuous with the internal elastic membrane of the tunica intima. The proximal surface of the valve was devoid of elastic fibers.

In normal saphenofemoral junctions the sinus wall was only slightly thinner than

the wall of the adjacent portions of the saphenous vein. (Fig. 3.) Although somewhat less distinct all coats of the vessel wall were identifiable. The internal elastic membrane was less conspicuous but was nevertheless present and was directly continuous with that covering the more proximal segment of the saphenous vein.

In defective saphenofemoral junctions the sinus wall was thinner from one-half to one-fifth of the normal thickness. (Fig. 4.) The tunica intima contained no internal elastic membrane although in a few cases scattered, short, ill-defined elastic fibers were present. (Fig. 5.) The tunica media, when recognizable as such, disclosed only a few small bundles of smooth muscle, a more abundant amount of collagenous connective tissue and only scattered elastic bundles. Not infrequently, particularly at the base of the valve leaflets, there were no muscle bundles whatsoever and the few collagen bundles that formed this coat

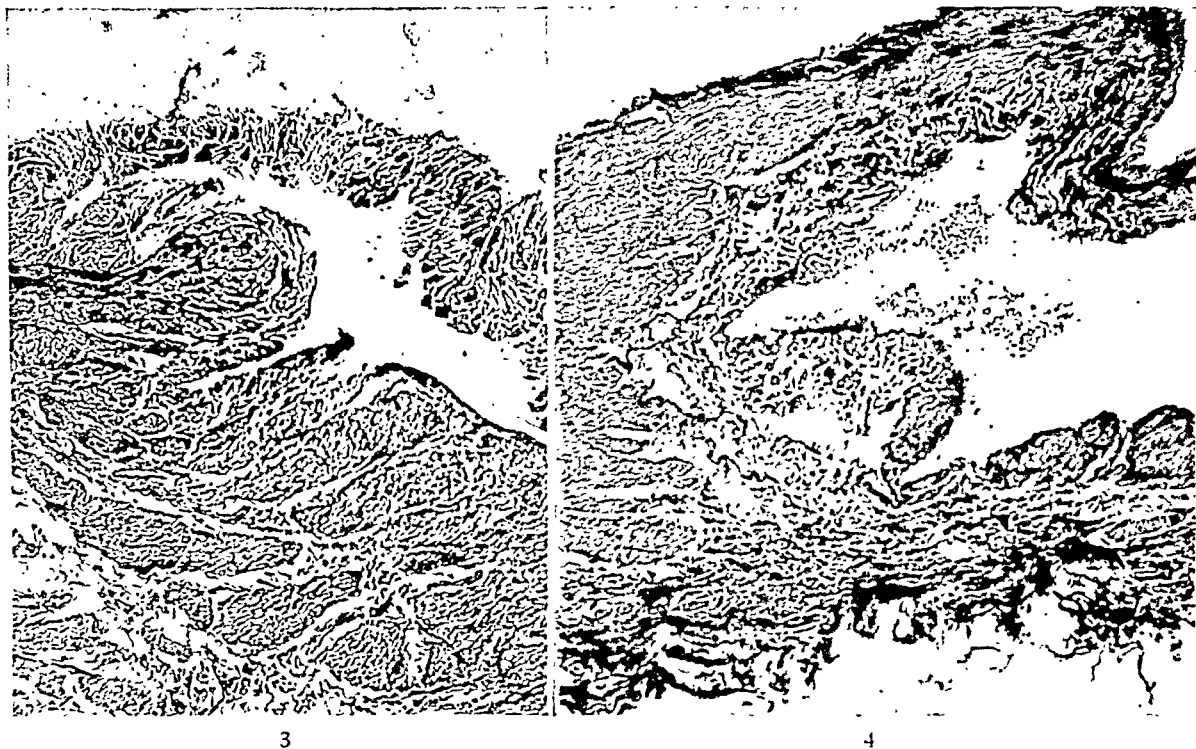


FIG. 3. Normal saphenous sinus wall; the tunica intima contains elastic fibers. The tunica media is thick and composed of well developed muscle bundles, collagen bundles and elastic fibers; note the elastic fibers covering the distal surface of a valve leaflet. (Elastic tissue stain  $\times 75$ .)

FIG. 4. Defective saphenous sinus wall showing a thinning of the coats, an absence of an internal elastic lamina of the tunica intima and of muscle bundles of the tunica media and a paucity of elastic fibers in the middle coat. (Elastic tissue stain  $\times 75$ .)

were intimately blended with the tunica adventitia. The latter varied in thickness from that covering other portions of the vein to a layer about one-third or one-quarter that of normal. The proportion of collagen bundles to elastic fibers did not differ from that in other portions of the saphenous vein.

Nine femoral veins were sectioned in the valve area located just above the entrance of the saphenous vein for comparison with the saphenous veins. In each the sinus wall was similar to that found in the sixteen normal saphenofemoral junctions. (Fig. 6.) None showed the defects encountered in the remaining eighty-four specimens.

#### COMMENTS

Thinness of the saphenous vein wall at the sinus area of the valve was of such frequent occurrence in this series as to suggest its normalcy in the majority of cases. That an attenuation in this area of

the wall is of normal congenital and developmental origin was first shown by Kampmeier and Birch<sup>1</sup> who studied the embryologic development of the venous valves in the human fetus and newborn. They observed that in the final stage of formation of the valves and their sinuses there was a bulging of the vein wall sequential to a local retardation in growth and a deficiency in circular muscle development of the tunica media. At such points in the newborn the latter was only one-fourth to one-fifth as wide as elsewhere in the vein. The disparity in the thickness of the wall and in the disposition of the muscle fibers was interpreted as having importance in the functioning of the valve.

Granted that a certain degree of thinning of the venous wall at the sinus area is normal, it must be conceded that there are limits beyond which the condition must be regarded as definitely abnormal. Loss of circular muscle fibers is the rule but some



FIG. 5. Defective saphenous sinus wall from another case at a higher magnification showing complete absence of muscle bundles and a paucity of elastic fibers. (Elastic tissue stain  $\times 200$ .)



FIG. 6. Normal femoral sinus wall showing a structure similar to that of a normal saphenous sinus wall illustrated in Figure 3. (Elastic tissue stain  $\times 37.5$ .)

muscle, usually longitudinal fibers, as well as some form of elastica should be present. According to the studies of Clark<sup>2</sup> smooth muscle in a state of tone should form a physiologic first line of defense against distention of the vessel wall. When this resistance has been completely overcome, the fibro-elastic components are forced to take over. It is thus likely that a sinus wall in which there is complete absence of muscle as well as internal elastic membrane will eventually dilate under the repeated stress of internal mechanical forces.

The most formidable of the hemodynamic or aggravating forces is probably the hydrostatic pressure which is considerably higher in humans than in lower animals because of the erect posture. The importance of the role played by this pressure is emphasized by the fact that varicose veins as seen in man do not occur in quadrupeds. Furthermore, as pointed out by Eger and Casper,<sup>3</sup> in those individuals with absence of valves in the external iliac

and femoral veins above the orifice of the great saphenous an even greater burden of support is imposed on the valves of the latter vessel. Increase in intra-abdominal tension in pregnancy, pelvic tumors, heavy muscular work with straining at lifting and repeated straining at stool exert pressure on the pelvic veins, thus retarding the venous return. Finally, occupations requiring standing for long periods favor stasis by curtailing the massaging action of muscular contractions on the deep veins, thus retarding the emptying of the superficial veins.

In predisposed individuals the actual varices rarely manifest themselves before adolescence for the following reasons: The hydrostatic pressure reaches its maximum only when full height has been attained; the elasticity of skin and veins is greatest during this period and the diameter of veins relatively smaller; muscular movements are more active and more constant, thus increasing the return flow of blood and encouraging drainage of the superficial veins; the veins are still growing in length; and occupations involving protracted periods of standing are seldom required.

It is significant that in this study the valve leaflets themselves were histologically normal in all instances including the cadavers with varicose veins. Although congenital absence of valves, degeneration with increasing age and destruction by thrombophlebitis have been reported, we do not believe that such valve defects *per se* constitute a common cause for the development of varicose veins. Indeed, it is much more probable that in the usual case the valvular insufficiency is purely functional and secondary to dilatation of the vein wall.

With regard to the hereditary tendency toward the development of varicose veins there is little dispute. Figures indicating this influence vary between 40 per cent<sup>4</sup> and 65 per cent.<sup>5</sup> If blood relatives other than siblings or parents are included, the percentage is approximately 90 per cent. It has been observed that not only may several members of the same family in succeeding generations have varicosities but also the pattern of the involved veins may be similar in all. It is reasonable to suspect that such defects might be on an embryologic or developmental basis. For this reason we sought a muscular defect in the tunica media at the bifurcation angle of the saphenofemoral junction. Such a defect was described by Forbus<sup>6</sup> for arteries in the circle of Willis bearing congenital berry aneurysms and was recently encountered by us in a case of aneurysm of the inferior pancreaticoduodenal artery.<sup>7</sup> In each instance, however, the muscle coat of the saphenous vein showed no evidence

of faulty fusion with the muscle coat of the femoral at the junction of the two veins. The structural defect was found instead at the sinus wall of the vein.

#### SUMMARY AND CONCLUSIONS

1. Absence of smooth muscle and internal elastic membrane in the sinus wall of the great saphenous vein in the valve area at the saphenofemoral junction is fairly common.
2. This defect may be congenital and possibly hereditary.
3. It is possible that such defects in other perforator veins would predispose to dilatation under the constant stress of hemodynamic forces, rendering the corresponding valves functionally incompetent and permitting retrograde flow of blood from the deep into the superficial veins.

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# EFFECTS OF URONIC ACIDS, PECTINS AND PECTINATES ON THE ENTERIC FLORA, ALONE AND IN COMBINATION WITH ANTIBIOTICS\*

## I. IN VITRO STUDIES

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RECENT clinical and experimental work by Mast and Harrison<sup>1</sup> has indicated that various pectins, pectinates and uronic acids when given alone by mouth possess no potent *in vivo* antibacterial properties but become extremely powerful bactericidal agents in the gastrointestinal tract when given together with oral streptomycin. In combination these drugs far surpassed the ability of streptomycin alone to eliminate intestinal organisms. There were important advantages possessed by these combinations regarding subsequent development of streptomycin resistance by the enteric flora. They found it possible to sterilize the feces completely in several patients and to eliminate all but a few spore-forming anaerobic organisms in others. This work has since been confirmed by Pulaski<sup>2</sup> and further by our own clinical studies now in progress.

The ability of pectin compounds to give subjective relief in cases of various diarrheas has been known for many years and dates from the discovery of the beneficial effect of scraped apple diets in these conditions. This effect of pectins has been attributed to their ability to adsorb toxins and enmesh offending organisms, to become hydrophylic to an extreme degree, thus removing excess water from the intestinal tract, and to their mechanical ability of coating the intestinal wall with a smooth, protective and soothing carbohydrate film.

Laboratory studies investigating the antibacterial properties of pectins have

revealed several interesting findings. Many investigators have held that the pectins alone possess no antibacterial properties except by virtue of their low pH values in solution. However, when pectins exist in the form of metallic pectinates, certain of the salts become bactericidal both *in vivo* and *in vitro* and such activity has been distinct from pH effect. The pectinate most investigated has been the nickel salt. It has been shown by Haynes and associates<sup>3</sup> and by Myers and Rouse<sup>4</sup> that the presence of small amounts of nickel incorporated into the molecule as nickel pectinate rendered that salt definitely bactericidal. It has also been shown by Myers and Rouse<sup>4</sup> and by Arnold<sup>5</sup> that silver pectinate is even more efficient in this respect and that copper pectinate has a definite toxic action on the *Staphylococcus aureus*. The amounts of metal in those dry preparations are extremely small and vary from 0.3 to 0.5 per cent. Of this material, solutions of only 1 to 5 per cent have exhibited their strongly antibiotic properties. It is evident that the bactericidal properties of these pectinates cannot be accounted for only on the basis of their slight metal content.

The composition of the many pectins, while varying in some respects, consists of several essential components among which are galactose, arabinose, acetic acid and galacturonic acid.<sup>4,6</sup> Of these, galacturonic acid makes up 87 to 95 per cent of the total and is obtained in the hydrolysis of the complete pectin. There is a possibility

\* Studies, observations and reports from the Department of Dermatology of The Barnard Free Skin and Cancer Hospital and the School of Medicine, Washington University, St. Louis, Mo. This work was accomplished under a grant from the Commercial Solvents Corporation.



that the antibacterial properties of the pectin, when given orally with streptomycin, are due to the breakdown of the pectin molecule with liberation of large amounts of galacturonic acid as the active antibacterial principle.<sup>1</sup> When given orally with streptomycin this acid seems to be

fold: first, to ascertain whether or not various pectins and uronic acids possess significant antibacterial properties themselves and, second, whether those compounds in combination with various antibiotics show the synergism *in vitro* that exists in the gastrointestinal canal.

TABLE I  
PH OF PECTIN, PECTINATE AND URONIC ACID  
AQUEOUS AND BROTH SOLUTIONS

	Concentration of Solutions															
	1 1/4 %		1 1/2 %		1 %		1 1/2 %		2 %		3 %		4 %		5 %	
	Broth	Aqueous	Broth	Aqueous	Broth	Aqueous	Broth	Aqueous	Broth	Aqueous	Broth	Aqueous	Broth	Aqueous	Broth	Aqueous
7% methoxyl pectinic acid. . . . .	...	...	6.0	5.0	5.5	4.4	5.0	4.0	4.5	3.8	4.2	3.6	3.9	3.4	3.7	3.2
5% methoxyl pectinic acid. . . . .	...	...	6.5	5.3	5.9	4.7	5.5	4.2	5.3	3.9	5.0	3.7	4.7	3.4	4.5	3.2
Bismuth pectinate. . . . .	...	...	6.5	4.2	6.0	3.7	5.6	3.5	5.1	3.4	4.5	3.2	4.0	3.1	3.5	2.8
Aluminum pectinate. . . . .	...	...	7.0	4.2	6.3	3.8	6.0	3.5	5.5	3.4	4.4	3.2	4.0	3.0	3.7	2.8
Silver pectinate. . . . .	...	...	5.5	4.0	5.0	3.8	4.8	3.7	4.5	3.6	4.0	3.5	3.7	3.2	3.3	3.0
Galacturonic acid hydrate. . . . .	5.0	3.6	4.5	3.4	3.7	3.2	3.4	2.8	3.0	2.5	2.7	2.2	2.4	1.8	1.9	1.5
Glucuronolactone. . . . .	6.8	5.0	6.5	4.7	6.2	4.5	5.8	4.2	5.5	3.9	4.8	3.5	4.4	3.3	4.0	3.0

even more effective than pectin. A closely related compound, glucuronic acid, is similarly effective. Following the administration of these materials it has been found that the portion of the intestinal canal in which feces are sterile, or nearly so, is the lower colon. It has not yet been determined whether or not this is true for the small bowel. It is in the colon also that Werch and his associates<sup>7</sup> found the breakdown of pectins to occur. They discovered the decomposition of the pectin to be due to the action of several organisms all of which were non-pathogenic and which constituted part of the normal enteric flora. They also found that both pectins and galacturonic acid were very slightly absorbed and, in the main, were excreted unchanged in the feces.<sup>8</sup> They acknowledged that both pectins and galacturonic acid were lethal to pathogenic organisms under certain conditions but thought that this was a pH function.

The purpose of this study has been two-

Throughout the following experiments the test organisms employed were beta-hemolytic streptococci, *Staph. aureus*, *Pseudomonas aeruginosa* and *Escherichia coli*. All were freshly isolated from patients. The culture medium throughout was tryptose broth (Difco). The test substances investigated included 7 per cent methoxyl pectinic acid, 5 per cent methoxyl pectinic acid, bismuth pectinate, aluminum pectinate, silver pectinate, galacturonic acid hydrate and glucuronolactone. The latter compound is a stable inner anhydride which becomes glucuronic acid in solution. These solutions were all prepared by stirring the powder into cold water and then dissolving it with as little heat as possible. Sterilization was accomplished at 15 pounds' pressure for twenty minutes. Following inoculation with the test organisms the solutions were incubated for twenty-four to forty-eight hours at 37°C. After that time the cultures were examined for macroscopic growth. Cultures showing no apparent growth were

subcultured on tryptose broth to check their apparent sterility further.

The pH of various aqueous and broth concentrations of the test materials is shown in Table I.

Because it was found that the beta-

TABLE II

GROWTH OF TEST ORGANISMS IN TRYPTOSE BROTH AT ADJUSTED PH LEVELS

pH	Organism		
	Ps. aeruginosa	S. aureus	E. coli
7.0	+	+	+
6.0	+	+	+
5.5	+	+	+
5.0	+	+	+
4.5	+	+	+
4.0	+	+	+
	growth diminished at pH 4.0	growth diminished at pH 4.0	growth diminished at pH 4.0

hemolytic streptococcus would not grow even in very small concentrations of the test compounds, it was not included in many of the following experiments. The remaining three organisms, however, were incubated in tryptose broth adjusted to diminishing pH values by the addition of hydrochloric acid as is shown in Table II. It was thus shown that all tested organisms would grow well down to and including a pH of 4.5. At a pH of 4.0 growth was still visible but was less than in the higher pH range. (Table II.)

With this information at hand experiments were then undertaken to determine the concentrations of solutions of pectins, pectinates and uronic acids which might prove bactericidal. These data are presented in Tables III, IV and V.

It was therefore found that unbuffered solutions of all the tested compounds possessed antibacterial properties and, moreover, that such properties were not dependent on pH as bactericidal action was apparent at pH ranges well above that lethal to the test organisms. The pectinic acids were the least potent in that respect; the pectinates with the exception of the

silver salt were intermediate and the most effective were silver pectinate, the galacturonic and glucuronic acids. Although our

TABLE III

GROWTH OF TEST ORGANISMS IN DILUTIONS OF PECTINS AND PECTINATES IN TRYPTOSE BROTH

Preparation	Concentration of Solution (Per cent)	Organisms		
		Ps. aeruginosa	S. aureus	E. coli
7% methoxyl pectinic acid	5	—	—	—
	4	—	—	—
	3	—	—	—
	2½	—	+	+
	2	+	+	+
	1½	+	+	+
	1	+	+	+
	½	+	+	+
5% methoxyl pectinic acid	5	—	+	+
	4	+	+	+
	3	+	+	+
	2½	+	+	+
	2	+	+	+
	1½	+	+	+
	1	+	+	+
	½	+	+	+
Bismuth pectinate	5	—	—	—
	4	—	—	—
	3	—	+	—
	2½	—	+	+
	2	—	+	+
	1½	+	+	+
	1	+	+	+
	½	+	+	+
Aluminum pectinate	5	—	—	—
	4	—	—	—
	3	—	+	—
	2½	+	+	+
	2	+	+	+
	1½	+	+	+
	1	+	+	+
	½	+	+	+
Silver pectinate	5	—	—	—
	4	—	—	—
	3	—	—	—
	2½	—	—	—
	2	—	—	—
	1½	—	+	—
	1	—	+	—
	½	+	+	—

work has included only 5 and 7 per cent methoxyl content pectins, it would seem that the pectin with the highest methoxyl

TABLE IV  
GROWTH OF TEST ORGANISMS IN SOLUTIONS OF URONIC ACIDS WITHOUT ALTERED PH LEVELS

	Ps. aerugenosa					S. aureus					E. coli				
	1/4%	1/2%	1%	1 1/2%	2%	1/4%	1/2%	1%	1 1/2%	2%	1/4%	1/2%	1%	1 1/2%	2%
Glucuronolactone.....	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Galacturonic acid hydrate.....	+	-	-	-	-	+	-	-	-	-	+	-	-	-	-

TABLE V  
GROWTH OF TEST ORGANISMS IN SOLUTIONS OF URONIC ACIDS BUFFERED TO PH 5.5

	Ps. Aerugenosa					S. aureus					E. coli				
	1/4%	1/2%	1%	1 1/2%	2%	1/4%	1/2%	1%	1 1/2%	2%	1/4%	1/2%	1%	1 1/2%	2%
Glucuronolactone.....	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Galacturonic acid hydrate.....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

TABLE VI  
DILUTION SERIES OF TEST COMPOUNDS OF SUBLETHAL CONCENTRATIONS IN TRYPTOSE BROTH SOLUTION AND COMBINED WITH STREPTOMYCIN  
(TEST ORGANISM PSEUDOMONAS AERUGENOSA)

Preparation	Concentration of Streptomycin															
	100μ/cc.	50μ/cc.	25μ/cc.	10μ/cc.	5μ/cc.	2.5μ/cc.	1μ/cc.	0.5μ/cc.	0.25μ/cc.	0.1μ/cc.	0.5μ/cc.	0.025μ/cc.	0.01μ/cc.	0.005μ/cc.	0.0025μ/cc.	Control
A. Control, tryptose broth alone.....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
B. 0.5% of 7% methoxyl pectinic acid.....	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
C. 1.5% of 7% methoxyl pectinic acid.....	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
D. 0.5% of 5% methoxyl pectinic acid.....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. 1.5% of 5% methoxyl pectinic acid.....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
F. 0.5% of bismuth pectinate.....	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
G. 0.5% of aluminum pectinate.....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
H. 0.5% of silver pectinate.....	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
I. 0.5% of galacturonic* acid hydrate.....	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+
J. 0.5% of galacturonic acid hydrate (pH 5.5)...	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
K. 0.2% of galacuronolactone (pH 5.5).....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

\* 0.5 per cent of unbuffered galacturonic acid hydrate is bactericidal for this organism. This dilution series was included, however, to illustrate again the difference in the action of buffered and unbuffered galacturonic acid.

content was consistently the most bactericidal. It would also seem that glucuronic acid was slightly more potent in unbuffered solution than was galacturonic acid but, when adjusted to a pH of 5.5 with sodium hydroxide, there was a very noticeable difference between the antibacterial properties of the two compounds. At the adjusted pH level the galacturonic acid permitted heavy growth of the test organisms in all concentrations. This was in agreement with the findings of Steinhaus and Georgi.<sup>9</sup> The glucuronic acid, however, remained as effective in killing the test organisms at pH 5.5 as before neutralization although at the higher pH considerable of the acid was converted into sodium glucuronate.

With the aforementioned facts established it was then necessary to find whether the addition *in vitro* of several antibiotics in varying amounts to sublethal broth concentrations of pectins, pectinates and the uronic acids produced any such remarkable bactericidal effects as when these compounds were given orally with streptomycin. Therefore, eleven types of dilution series were set up with each type set against all possible combinations of the three test organisms and the four antibiotics, namely, streptomycin, penicillin, bacitracin and tyrothricin. Since this amount of tabular material cannot be presented, a single, representative, eleven-series' table is shown in Table VI. In this table the poor effectiveness of streptomycin against the *Ps. aeruginosa* is due to the low pH of the solution, at which levels streptomycin loses much of its potency.

From Table VI it may be seen that the combination of the streptomycin with test compounds did produce a mild degree of synergism even though the test substances were all well below their bactericidal concentrations. This synergism did not, however, approach that which functions clinically. Approximately the same degree of synergism existed with penicillin, bacitracin and tyrothricin as was found with streptomycin. There was no change in the

effective spectrum of any of these antibiotics due to their combination with the test compounds. Organisms resistant to a given antibiotic showed no change in that resistance due to combination with either the pectins, pectinates or uronic acids.

It is interesting that the test organism found to be most affected by these compounds was the *Ps. aeruginosa*. This organism has always been a difficult one with which to work both clinically and in the laboratory.

#### COMMENTS

It would appear that the work of Mast and Harrison<sup>1</sup> offers the first opportunity for almost completely sterilizing the contents of the lower colon. Whether or not higher levels of the gastrointestinal tract are similarly sterilized is now being studied. Repeated publications by Lockwood<sup>10,11</sup> as well as others have shown that streptomycin alone could not accomplish such sterilization.

As was said before, there have been much controversial data regarding the antiseptic power of the pectins, pectinates and uronic acids employed in this present work. It is hoped that this study will clarify that portion of the problem and leave the way open for further investigation as to the synergism which operates when these two widely different classes of compounds are combined in the gastrointestinal canal.

Needless to say, a technic by which any or all of the gastrointestinal tract can be sterilized offers numerous possibilities for further study. The physiologic effect on the host, the more satisfactory preparation for gastrointestinal surgery and the further study of conditions in which enteric auto-intoxication has been held as an etiologic factor are only a few of these. Such studies are now in progress by the authors at this and associated institutions.

#### CONCLUSIONS

1. Explanatory data are presented regarding the ability of streptomycin given

together with either pectins, pectinates or uronic acids to sterilize the contents of the lower colon.

2. The chemistry and biochemistry of the pectins, pectinates and uronic acids are briefly discussed and data are presented to show that these compounds possess varying degrees of antibacterial potency.

3. It is shown that only a slight degree of synergism exists *in vitro* between these compounds and streptomycin as well as with other antibiotics. No such degree of synergism exists *in vitro* as apparently is the case in the human gastrointestinal tract.

4. Discussion is presented indicating the importance of a technic which will permit sterilization of all or part of the gastrointestinal canal.

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# Streamlined Articles

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## CAROTID BODY TUMORS

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NOT many surgeons have operated upon or are acquainted with the clinical picture of carotid body tumors. Only 293 cases have been reported in the literature up to the present. Because of the rarity of the condition a critical review of the literature was made and an additional case associated with carcinoma of the urinary bladder reported.

The diagnosis of carotid body tumor is seldom made or even entertained. They are symptomless tumors and of many years' duration. Fifteen per cent of these tumors are malignant. The majority of them envelop the carotid arteries and jugular vein. The treatment of choice is surgical removal. The magnitude of the surgical procedure is influenced by the necessity of ligation of one, two or three carotid vessels. This procedure, however, increases the mortality and morbidity of the patient. Radiation therapy is recommended for inoperable cases.

It is hoped that this article will stimulate further thought on the subject of carotid body tumors.

\* \* \* \*

In 1929 Bevan and McCarthy<sup>1</sup> stated that very few surgeons have operated upon more than one patient, a few have operated upon two patients and no one has operated on more than three. This statement generally still holds true, with certain exceptions. Since that excellent article was written, Rankin and Wellbrock<sup>2</sup> reported twelve cases in 1931. Hertzler<sup>3</sup> reported seven personal cases in 1937. Harrington et al.<sup>4</sup> reported nineteen cases in 1941 and Lahey

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and Warren<sup>5</sup> reported eighteen cases in 1947. The aforementioned articles and that of Keen and Funke<sup>6</sup> have formed a very sound foundation for the further study of tumors of the carotid body.

Carotid body tumors retain the shape, lobulation and encapsulation of the normal carotid body as well as the histology, but on a larger scale. They vary in size from a hazelnut to an orange. The largest tumor described by Reid<sup>7</sup> weighed 190 Gm. Firm pressure will diminish its size by forcing the blood out of the highly vascular mass. Some writers described the tumor grossly as resembling a kidney while others compare it to the thyroid gland. The tumor is almost always unilateral although eight bilateral cases were reported. Lund<sup>8</sup> mentions a case in which a second tumor appeared in the opposite side of the neck twenty-nine years after removal of the first one. The right and left sides are equally involved. Male and female are almost equally affected. The oldest patient reported in the literature was seventy-three and the youngest seven; the average age is between thirty and forty years. Heredity does not influence the growth of these tumors although Chase<sup>9</sup> reports two members of the same family with carotid body tumors.

The tumor is of a firm, rubbery consistence. The surface is smooth although in some instances it may be nodular. The color varies from grey-red to purple-red. It is not attached to the skin but is fixed to the underlying structures. It is freely movable from side to side but not from above downward. It practically always

pulsates but the pulsation is not that full expansion and contraction of an aneurysm but a transmitted pulsation from the carotid vessels. In some cases the tumor may bulge into the pharynx while in others it may extend to the base of the skull. As the tumor grows in size, it envelops the carotid vessels and jugular veins in the majority of cases; or it may involve or press upon the glossopharyngeal, hypoglossal, vagus, phrenic or superior cervical sympathetic.

Very few cases of malignancy of carotid body tumors are reported. Bevan and McCarthy state that unless tumor cells can be demonstrated invading the tumor capsule or vessel walls with or without regional lymph node involvement, it is very difficult, if not impossible, to make a diagnosis of malignancy. They state that not more than 15 per cent of the tumors are malignant. Rankin and Wellbrock reported a case of bilateral carotid body tumor that was malignant on the left side and benign on the right. Cragg<sup>10</sup> reported a case of concurrent tumor of the left carotid body and bilateral Zuckerkandl's bodies.

The malignant tumors rarely, if ever, result in distant metastasis. Ewing<sup>11</sup> states, "General metastases are not observed." This opinion is also held by Willis.<sup>12</sup> Local extension with involvement of the regional lymph nodes is not uncommon in malignancy of the carotid body. Recurrence may take place even in benign tumors if they are not completely removed.

The clinical diagnosis of carotid body tumor is seldom made or even considered as a differential diagnosis in tumors of the neck. It is a symptomless tumor which occurs in the upper anterior cervical triangle and which may exist for many years. The average duration of the tumor before the patient came to the surgeon complaining of a swelling in the neck was 5.7 years. The longest time was thirty-five years. Symptoms may be present when the tumor bulges into the pharynx or presses on the vagus, cervical sympathetic or recurrent laryngeal nerves. Pressure symp-

toms may be manifested by headache, dizziness, hoarseness, cough, dysphagia or fainting spells. Stokes-Adams syndrome and Horner's syndrome have been reported in several cases.

The differential diagnoses in order of importance and frequency are metastatic tumors, lymphoma, tuberculoma, neurofibroma, branchial cysts, aberrant thyroid and aneurysm. Bronchogenic cysts are most likely to resemble clinically tumors of the carotid body. If clinical evaluation fails to establish a diagnosis and aneurysm is definitely ruled out, a biopsy would not only establish a diagnosis but would also dictate the mode of treatment.

The treatment of choice of tumors of the carotid body is complete surgical removal without ligation of the carotid vessels if possible. The magnitude of the surgical procedure is influenced by the necessity of ligation of one, two or three carotid vessels. This in turn depends on the fixation of the vessels to or into the tumor substance. In many instances the tumor completely envelops the vessels and fuses with them making their dissection from the tumor impossible. Important nerves of the neck may be similarly incorporated into the tumor substance although not as frequently. Ligation of the common carotid artery in adults, particularly those who are in the latter half of middle age or beyond, is an extremely serious procedure which carries with it a high rate of mortality, 30 to 65 per cent (Rankin and Wellbrock). In their series of twelve cases it was necessary to ligate the common carotid artery in three cases. All of the patients died within the first forty-eight hours. Harrington et al. report a mortality of 20 per cent which they attribute in most part to hemiplegia. The average age of the patients who died following ligation was fifty-three while the average age of those who survived ligation was thirty-one. In Keen and Funke's twenty-six cases four patients died from pneumonia following resection or division of the vagus nerve and five died from hemiplegia, aphasia and

acute edema of the lungs. In three the voice was affected.

Phelps, Case and Snyder<sup>13</sup> reviewed 154 cases of which 148 patients were operated upon with a mortality of 24 per cent. The mortality was 30 per cent in the group of patients in which carotid ligation was necessary. Seven per cent of those who recovered following ligation of the carotid artery had cerebral complications.

According to Dickenson and Traver in 50 per cent of the reported cases it has been necessary to sacrifice the common carotid artery which has resulted in the death of 30 per cent of the patients. Half of those who survive will have permanent brain damage.

Keen comes to the following conclusion: "The symptoms and inconvenience of the tumor of the carotid body are generally so slight that I do not think any patient who is not suffering seriously or where the tumor does not exhibit symptoms of malignancy or a rapid growth should be subjected to the grave dangers which such operation may involve. Surely no prudent surgeon would be willing to cause his patient to face such dangers simply for cosmetic purposes. If, on the other hand, the tumor is growing rapidly and presents a malignant appearance, then I believe operation is justified, but not otherwise."

Considering the difficulty in diagnosing carotid body tumors, the clinical uncertainty of their malignant nature and the fact that carotid ligation is not always necessary, one would rather agree with the conclusion of Lahey and Warren that "all laterally located, discrete and movable tumors of the neck should be explored." Only through exploration and the taking of a biopsy can one determine not only the nature of a primary tumor of the neck but the operability and prognosis. Bevan and McCarthy believe that neoplasms of the carotid body should not be removed when it is necessary to ligate the common carotid artery in order to complete the operation. They recommend local anesthesia as best for this operation.

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FIG. 1. Photomicrograph shows papillary carcinoma of the urinary bladder.  $\times 50$ .

Harrington et al. recommend preoperative systemic compression of the common artery against the transverse process of the sixth cervical vertebra several times a day for a few weeks, with the hope of developing collateral circulation in the brain on the affected side. Compression should be carried out for gradually increasing periods until the patient can tolerate complete compression of the vessels for a long period without experiencing faintness or loss of consciousness.

Lahey and Warren state that the common carotid artery should be gradually compressed until the patient can tolerate complete compression for a period of ten minutes three times a day without any symptoms. They also state that if the common, internal and external carotids are ligated, it should be accompanied by ligation of the internal jugular vein.

Radiation therapy in inoperable carotid body tumors has not been given a sufficient trial to form a conclusion as to its application. Bevan and McCarthy report good results in one case of carotid body tumor that was explored but not removed. Lahey and Warren report three cases in which patients were treated with radiation therapy resulting in slight reduction in the size of the tumor in each instance. Phelps, Case and Snyder, on the other hand, report seven proved cases of carotid body tumors treated by radiation without appreciable





FIG. 2. Gross specimen of the carotid body tumor shows capsule (A) with its septi dividing it into lobules (B) and terminating at the hilus in a pedicle, the ligament of Mayer, (C).

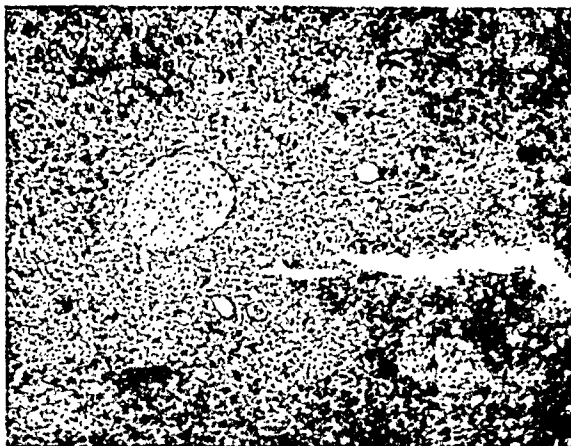


FIG. 3. Photomicrograph shows the histologic structure of the tumor.  $\times 140$ .

results. One may therefore conclude that if a carotid body tumor is explored and found inoperable, radiation therapy may be given a trial.

#### CASE REPORT

The patient was first seen on October 11, 1943, in the elevator as he went up to be admitted for carcinoma of the urinary bladder. When questioned about the swelling on the left side of his neck, he replied unconcernedly, "Oh, that! That is nothing. I have had it more than two years and it does not bother me."

The patient was a white male, aged seventy-two, weighing 119 pounds. He was in fairly good condition. His blood pressure was 170/100. He was transferred to the Brooklyn Cancer Institute from another hospital with a diagnosis of carcinoma of the urinary bladder. No mention was made on the transcript about a tumor of the neck. His past history and family history were essentially negative except for a dry, non-productive cough of two years' duration.

The tumor on the left side of his neck was about the size of an orange, extending from the angle of the mandible to the upper border of the clavicle and partially covered by the sternocleidomastoid muscle. It was of a soft, rubbery consistency, somewhat nodular, partially fixed to the underlying structures but not to the skin. It was somewhat movable from side to side but not from above downward. The skin appeared intact. A transmitted pulsation was present but no bruit. Slight traction on the tumor produced a cough similar to the one he had had for the past two years. Roentgen and

fluoroscopic examination of the neck only corroborated the diagnosis of a soft tissue tumor. The chest x-ray was negative.

The biopsy of the tumor in the urinary bladder was reported as papillary carcinoma. (Fig. 1.) The cardiogram showed myocardial damage with occasional premature contraction. The red count was 3,380,000 with 72 per cent hemoglobin; the white count was 14,000 with 80 per cent polymorphonuclears, 17 lymphocytes and 3 per cent monocytes. The blood urea 24 mg., creatinin 1.9, sugar 100, cholesterol 170, serum acid phosphatase 3 and serum alkaline phosphatase 6.8; the blood Wassermann test was negative.

On October 20, 1943, the patient was taken to the operating room. Under local anesthesia of 1 per cent novocain an incision was made along the anterior border of the sternocleidomastoid from the angle of the mandible to the upper border of the clavicle. A soft, encapsulated nodular tumor was found extending from the angle of the mandible to 2 cm. beneath the clavicle. The capsule appeared to fuse with the carotid sheath and was surrounded by dilated veins and fine nerve fibers. It was only partially adherent to the carotid vessels. When the carotid sheath was opened, the tumor was found to be attached by a pedicle to the crotch of the bifurcation of the common carotid artery. The tumor with its pedicle simulated a kidney with its ureter emerging from the pelvis. (Fig. 2c.)

The tumor was carefully freed from the surrounding structures by dull and sharp dissection. The tumor pedicle was first loosely clamped and the patient's reaction observed.

It was then doubly clamped, cut and ligated. The tumor was then removed in its entirety. Complete hemostasis was established and the wound was closed. The histologic report confirmed the diagnosis of carotid body tumor. (Fig. 3.)

The patient made an uneventful recovery. Ten days later the urologist fulgurated the bladder carcinoma and inserted radon seeds.

In August, 1944, the patient developed a moderate amount of hoarseness and laryngoscopic examination revealed a partial paralysis of the right vocal cord. The patient was then observed in the Outpatient Department at frequent intervals. In August, 1945, he was admitted to another hospital where he died from uremia. There was no recurrence of the tumor of the neck.

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# ULTRAVIOLET BLOOD IRRADIATION THERAPY (KNOTT TECHNIC) IN THROMBOPHLEBITIS\*

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SINCE the first report on the use of ultraviolet blood irradiation therapy in thrombophlebitis<sup>1</sup> was published, we have used this method in an additional eighteen cases of thrombophlebitis; of these eighteen, ten were acute and eight chronic. As a result of our experience and observations in these eighteen cases as well as the original thirteen we have come to the following conclusions:

Following the use of ultraviolet blood irradiation in *acute* thrombophlebitis we found that *pain* was the first symptom to disappear, the time of disappearance normally varying from two to twelve hours; very often some slight pain persisted as long as seventy-two hours. *Tenderness* along the course of the affected vein usually disappeared within two to six hours after all pain had subsided. *Fever*, when present, dropped to normal within forty-eight hours. If a concomitant suppurative process was present, the temperature usually remained elevated between 99° and 101°F. until drainage was effected. *Edema* was the last symptom to disappear, usually doing so one to twelve days after treatment was started. When present *coldness* of the affected extremity, insofar as the patient's observation could be relied upon, was relieved within eight to forty-eight hours.

Following the use of ultraviolet blood irradiation in *chronic* thrombophlebitis we found that *pain* was the first symptom to disappear, the time of disappearance ranging from forty-eight hours to two months. *Tenderness* along the course of the affected vein disappeared in time periods ranging from two days to two months following initial ultraviolet blood irradiation. *Fever*,

when present, was usually low grade and returned to normal within forty-eight hours after the first treatment. *Edema*, the last symptom to disappear, usually did so five days to two months following initial therapy. One patient with scar tissue present from previous surgery had no marked reduction in edema although all other symptoms disappeared.

In general the longer the patient had had thrombophlebitis before blood irradiation the longer he or she required before the various symptoms disappeared entirely.

\* \* \* \*

The blood irradiation treatments given to these patients were made possible by the use of the Knott technic and the Knott hemo-irradiator.<sup>2,3</sup> In this procedure a predetermined amount of blood was withdrawn from an antecubital vein (1.5 cc. per pound of body weight) and passed through the Knott hemo-irradiator. The latter is a precision machine which exposes the withdrawn citrated blood at a predetermined rate to ultraviolet rays from a water-cooled quartz mercury vapor lamp and returns the irradiated blood to the patient through the needle use for the initial venipuncture.

## CASE REPORTS

CASE 1. A twenty-five year old white female developed thrombophlebitis of both femoral veins following an uneventful delivery of a normal child. Her temperature was 103°F., pulse 160, respirations 40, white blood cells 30,000 and polymorphonuclears 92 per cent. With her phlebitis she complained of marked pain and tenderness in both legs and bilateral edema. Forty-eight hours following one ultra-

\* Aided by a grant from the Madison Foundation for Biochemical Research, New York, N. Y.

violet blood irradiation her temperature was 98.8°F., pulse 120, respirations 24, white blood cells 21,000 and polymorphonuclears 82 per cent. Pain, tenderness and edema had completely disappeared and subsequent convalescence was uneventful.

CASE II. A thirty-five year old white male was first seen September 9, 1947, as an out-patient. He gave a history of chronic thrombophlebitis in both lower extremities with deep involvement of both saphenous and femoral veins of twelve years' duration. His temperature was normal; he had pain and tenderness along the route of both saphenous veins and marked bilateral edema. Prior to seeing us he had run the gamut of treatment from bed rest, sulfa drugs and penicillin to surgery, including scarification and bilateral vein-stripping. After his initial ultraviolet blood irradiation all tenderness disappeared in thirty-six hours. Pain was noticeably less in twenty-four hours and was completely gone in four weeks following the initial ultraviolet blood irradiation. Swelling has not markedly disappeared mainly, we believe, as a result of scar tissue following previous surgery but it has receded greatly, appearing only while the patient is standing or walking. Since this treatment he has had one exacerbation of pain, fever and tenderness. This, however, was easily controlled within two days with the use of ultraviolet blood irradiation. Since that time, March, 1948, he has had no exacerbation, has returned to full activity and is complaint-free.

#### SUMMARY

1. In eighteen consecutive instances patients with acute or chronic thrombophlebitis were given ultraviolet blood irradiation therapy (Knott technic).

2. In the ten acute cases there was a rapid subsidence of pain and tenderness within twelve to forty-eight hours. Fever, when present, returned to normal within forty-eight hours and the edema usually disappeared by the twelfth day.

3. In the eight chronic cases the symptoms also disappeared but over a generally longer period of time, depending on the duration of the disease process prior to treatment.

4. There were no noticeable untoward effects either immediate or delayed.

5. The original findings are confirmed and extended.

6. The Knott technic of ultraviolet blood irradiation has been found a safe and efficient method of controlling acute and chronic thrombophlebitis.

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# SIX PRIMARY CARCINOMAS IN ONE PATIENT\*

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A CASE is reported in which there were six separate primary carcinomas involving respectively the jejunum, the transverse colon, the sigmoid colon, the rectosigmoid colon, the urinary bladder and the skin.

\* \* \* \*

## CASE REPORT

A fifty-three year old Caucasian male was hospitalized on February 11, 1947, because of severe stabbing pain in the right lower quadrant and perineum of six hours' duration.

He had been in good health until 1943, at which time he had developed hematuria; a bladder tumor had been excised through a suprapubic cystotomy. Thereafter the patient had no further complaints until the beginning of January, 1947, when he sought admission to another hospital where a cystoscopy was performed and a bladder tumor removed by fulguration. Both specimens were diagnosed as transitional cell carcinoma grade II.

Physical examination disclosed a well nourished, apprehensive male who appeared to be acutely ill and in pain. The abdomen was distended and tender in the right lower quadrant, with rebound tenderness throughout. Peristaltic activity was within normal limits; no masses were palpable. Rectal examination was negative. The patient's temperature was 101.6°F. by mouth. There was a leukocytosis of 16,300 with 89 per cent polymorphonuclear cells. The hemoglobin level was only 11.7 Gm. and the red cell count was 3.6 million. Urinalysis revealed thirty to forty pus cells per high power field. The first stool was soft and brown and manifested a strongly positive test for occult blood. X-ray of the abdomen revealed a moderate amount of gas in the small and large intestines.

With bed rest and parenteral feedings the

pain and fever subsided over the course of three days. However, on the fifth day the patient had another seizure of colicky pain in the right lower abdomen associated with a temperature rise to 103.4°F. Roentgen examination of the abdomen showed gaseous distention of the small intestine with intraluminal and extraluminal fluid. There was no gas visible in the large intestine. A diagnosis was made of intestinal obstruction due probably to an acute inflammatory process in the region of the terminal ileum.

At operation the appendix was found to have perforated into the pelvis; diffuse peritonitis involved the lower half of the peritoneal cavity. An appendectomy was performed. During the course of the operation a rosette-shaped mass 2½ cm. in diameter was palpated in the small intestine. A tentative diagnosis of carcinoma was made but excision was deferred in the presence of spreading peritonitis. The operative convalescence was complicated by a pelvic abscess which was drained through the lower abdominal wall.

During the postoperative recovery further studies were undertaken to determine the nature of the lesion in the small intestine. A gastrointestinal series with small bowel studies failed to demonstrate any abnormality. However, a barium enema disclosed two deformities of the large intestine, one in the right half of the transverse colon and the other in the proximal portion of the sigmoid colon. Both deformities had an appearance suggestive of carcinoma but in the presence also of a small intestinal lesion they were thought to be inflammatory in nature. The colon was normal up to 20 cm. from the anus by sigmoidoscopic examination. Stool studies for intestinal parasites were negative but the stools contained occult blood on a meat-free diet. During the convalescence the patient had daily afternoon rises of temperature to 99.4°F. and an elevated

\* From the Surgical Service, Birmingham Veterans Administration Hospital, Van Nuys, Calif. Sponsored by the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are a result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

sedimentation rate. There was a persistent hypochromic microcytic anemia which did not respond to iron therapy. Occasionally the patient complained of left lower quadrant abdominal discomfort relieved after an enema or the passing of flatus. The patient was on a full diet but there was no consistent weight gain. Although amebiasis had not been demonstrated in repeated stool examinations, the clinical picture was considered suggestive of amebic granuloma. The patient received two courses of emetine, each lasting seven days, and one course each of diodoquine and carbarsone. There was no apparent improvement.

On June 11th, four months after admission, celiotomy was performed. In the jejunum 15 cm. from the ligament of Treitz a hard, constrictive lesion measuring 3 cm. in its greatest diameter was found. The jejunal mesentery contained a group of enlarged lymph nodes, the largest measuring 1½ cm. in diameter. Their consistency and appearance were characteristic of metastatic carcinoma. In the right side of the transverse colon a short distance from the hepatic flexure there was an annular constrictive mass of stony hard consistency, 5 cm. in length and 3 cm. in width, covered by intact serosa. There was no associated lymphadenopathy. The proximal portion of the sigmoid colon contained an annular constrictive tumor measuring 6 by 5 cm. in area invading the serosa. There was mild lymph node enlargement in the sigmoid mesentery. Twice during the operation before resection was attempted the patient manifested a sharp drop in blood pressure and a rapid, thready pulse. Because of the patient's precarious condition the operation was restricted to a resection of the jejunal lesion and attached mesentery and an exteriorization of the neoplasm of the transverse colon by a modified Paul-Mickulicz procedure. Five days later the exteriorized mass was excised by cautery.

On July 17, 1947, the cancer of the sigmoid colon was resected and an end-to-end anastomosis was performed. At this time the remainder of the pelvic colon was normal to palpation.

The patient returned in January, 1948, for closure of the transverse colostomy. The two colostomy openings were dissected from the abdominal wall and the peritoneal cavity explored prior to reanastomosis. There was no evidence of metastasis in the liver or at any

of the sites of previous anastomosis. Several suspicious areas surrounding the jejunal anastomosis were biopsied and found free of cancer. However, a hard mass was found in the rectosigmoid colon about 6 cm. above the peritoneal reflection of the rectum; the serosa was intact and the mesenteric lymph nodes were not enlarged. Inasmuch as a permanent colostomy was probable, the previously exteriorized portion of the transverse colon was removed and a double loop colostomy made. The abdomen was then re-entered through a transverse incision in the left lower quadrant and the rectosigmoid colon excised. The proximal and distal segments of the intestine were closed and peritonealized.

In July, 1948, the patient had a sudden onset of left lower quadrant pain accompanied by nausea and vomiting. At operation a perforated ulcer on the anterior surface of the jejunum 2 cm. distal to the gastrojejunostomy was repaired. Later a small nodule developed at the site of pressure from a colostomy belt. This was thought to be a furuncle and was treated with warm moist compresses. Because the nodule grew larger and firmer under this regimen, it was excised for histologic study and was found to be a squamous cell carcinoma.

When seen two years after the jejunal resection, the patient manifested no clinical or laboratory evidence of persistence or recurrence of any of his carcinomas.

Microscopic examination of the tumors showed each to be a primary carcinoma with a distinct histologic structure. The jejunal tumor (Fig. 1) consisted of papillary masses of highly anaplastic, rapidly growing cuboidal to columnar cells invading the mucosa and submucosa. There were large areas of necrosis with infiltration by polymorphonuclear leukocytes. The mesenteric lymph nodes presented a similar microscopic appearance. The diagnosis was papillary adenocarcinoma of the jejunum with metastasis to the regional lymph nodes.

The excised portion of the transverse colon (Fig. 2) contained a tumor composed of columnar cells forming well differentiated glands invading the submucosa and muscularis. Mitotic figures were relatively few. A diagnosis of ulcerated adenocarcinoma of the transverse colon was made.

Sections of the sigmoid colon (Fig. 3) showed a malignant lesion composed of irregular glandular acini and alveoli of tumor cells invading the entire wall of the bowel. Although



FIG. 1. Anaplastic adenocarcinoma of jejunum consisting largely of solid masses of poorly differentiated cells with some tendency to form acini; some mucus production.

FIG. 2. Well differentiated adenocarcinoma within the submucosa of the transverse colon.

FIG. 3. Undifferentiated carcinoma of the sigmoid colon showing plaques and small acini with many signet-ring tumor cells containing mucus.

FIG. 4. Anaplastic adenocarcinoma of the rectosigmoid within the muscularis; note abundant mucus.

fairly cellular masses of signet ring tumor cells were found in places, some portions of the tumor consisted almost entirely of mucoïd material. Mucus-producing adenocarcinoma of the sigmoid colon was the diagnosis.

The lesion of the rectosigmoid colon was formed by irregular glandular structures which invaded the muscularis and extended into the serosa. The lining cells were highly anaplastic and contained abundant cytoplasm and much mucoïd material. There was also a large amount of mucus between the bundles of muscle fibers. Although both carcinomas of the sigmoid colon

contained a great deal of mucus, their microscopic pattern was distinctly different. (Figures 3 and 4.)

The tumor removed from the skin was described as a well differentiated keratinizing squamous cell carcinoma.

#### COMMENTS

This patient entered the hospital because of symptoms due essentially to acute appendicitis; otherwise, he might not have sought medical assistance. Cecal distention

secondary to partial obstruction of the distal colon<sup>1</sup> may well have entered into the etiology of the appendicitis. However, the jejunal cancer, although more extensive than the others, was apparently asymptomatic and was detected only by chance in the course of an unrelated operative procedure. Even after the presence of the small bowel lesion was known, roentgen studies failed to reveal it.

The two colonic lesions which were detected by barium enema examination confused the picture in the known presence of a small intestinal lesion. Despite an X-ray appearance which was rather characteristic of carcinoma, the simultaneous occurrence of these cancers in the small intestine, transverse colon and sigmoid colon seemed so unlikely that every possible device (including a therapeutic test with anti-amebic drugs) was used to prove that the lesions were granulomas.

All four intestinal carcinomas were separate primary growths, each with a distinctive histologic picture and all quite different from the transitional cell cancers previously removed from the bladder. Warren<sup>2</sup> has pointed out that the statistical expectancy of multiple primary malignancy should be only 5 or 6 per 1,000 whereas the observed incidence is 37 per 1,000. From this he concludes that there is a significant

element of susceptibility involved in the etiology of malignant neoplasms. In this case it seemed that the patient's tissues were especially prone to undergo malignant degeneration. The last tumor removed had encircled the bowel and extended into the serosa yet had not been palpable six months previously.

Frequently, as in this instance, the simultaneous occurrence in one patient of two or more unrelated neoplasms obscures the diagnosis because of the impression that primary malignancy is usually single. Actually the occurrence of one or more additional primary neoplasms in a patient already afflicted with one such lesion is six or seven times as likely as the first occurrence of a malignancy in an unafflicted individual. Multiplicity should be regarded as confirmatory rather than contradictory evidence of malignancy.

*Acknowledgment.* The authors wish to express their gratitude to Dr. Perry J. Melnick and Dr. Irving Reingold for their interpretation of the gross and microscopic pathology.

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# CARCINOMA OF CECUM IN YOUNG MAN OF TWENTY-ONE

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IN large bowel surgery a few words are apropos. No colon surgery should be done until the patient who is often debilitated and whose nutrition may be poor has been brought as close to normal status as possible. This can be accomplished by the administration of amino acids, blood transfusions and vitamin therapy. The use of sulfasuxidine or sulfathalidine which reduces the bacterial count of the bowel and renders the organisms less virulent (thus lowering the mortality of colon surgery) is an essential requirement preoperatively. In this case it would have been unwise to do any colon surgery at the time of the original operation because the bowel was not prepared properly with sulfasuxidine or irrigations.

\* \* \* \*

## CASE REPORT

A young man of twenty-one came into the hospital doubled up with pain. He appeared acutely ill and was groaning. He gave a history of intermittent pain for four months in the right lower quadrant which had become severe in the past four hours. There was no change in bowel habits.

Examination revealed tenderness and marked spasm in right lower quadrant. No mass could be palpated because of the spasm present. The laboratory report was as follows: white blood cells, 19,000; 91 per cent polymorphonuclears on admission; red blood cells 3,800,000; hemoglobin 80 per cent.

The condition of the patient was diagnosed as an acute exacerbation of a chronic appendix and operation decided upon. A right lower paramedian incision was made and the abdomen opened. On opening the abdomen, instead of an acute appendix, a large, firm mass involving the cecum was found. It looked and felt like a malignancy and there was some swelling and edema of the mass. It was thought advisable not to do anything at this time be-

cause of the nature of the lesion and because the bowel was not prepared for a formidable procedure. The abdomen was closed without drainage.

The patient was then prepared for two weeks with intravenous amino acids, intravenous fluids and sulfasuxidine, and multiple bowel irrigations before surgery.

With the patient under spinal anesthesia and with an intravenous drip going, a right paramedian incision was made from the costal margin downward toward the inguinal ligament. On opening the abdomen it was found that several adhesions had formed between the mass and the abdominal wall since the previous celiotomy. The liver showed no metastases. The mass was quite large and there were fairly large glands in the mesentery of the cecum but pathological examination showed these to be inflammatory. Then, because the patient was in good condition and because there was no obstruction in the tumor, a one-stage ileocolic resection using the Rankin clamp was performed with an end-to-side anastomosis between the ileum and the transverse colon.

During and immediately after operation the patient received a total of 1,000 cc. of citrated blood. Postoperatively, a Wangensteen suction was kept down for about three days prophylactically to keep tension off the anastomosis. The patient received about 3,000 cc. of intravenous fluids daily including amino acids and vitamins parenterally. After that he was started on water, then liquids and later soft diet. The wound healed *per primam* and the patient was out of the hospital in ten days.

Since operation the patient has gained 25 pounds in weight and has had no complaints.

The pathological diagnosis was adenocarcinoma of the cecum.

## SUMMARY

The preceding case was presented because the subject was relatively young for carcinoma of the colon and because of the method employed in handling the patient.

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# Case Reports

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## DESMOID TUMORS OF THE ABDOMINAL WALL

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**D**ESMOID tumors are of interest because they are uncommon and frequently are a problem in differential diagnosis. These tumors are important because they can be excised surgically with permanent cure if all of the tumor is removed. Miller (1838) first used the word "desmoid" to describe these benign tumors which arise from musculoaponeurotic structures. The word is well chosen as it represents a contraction of two Greek words, "desmos," a band or tendon, and "eidos," appearance.

Desmoids may develop in any of the striated muscles or their aponeuroses, for instance, in the pectoralis major, sternocleidomastoid, digastricus, masseter muscles, scapular region, biceps, extensor carpi ulnaris, rectus femoris, glutei or hamstring muscles. They do not appear in these regions, however, as frequently as they are found in the abdominal wall. This paper deals only with desmoids of the abdominal wall. In this region they occur most frequently in relation to the rectus muscle below the level of the umbilicus. Stone<sup>8</sup> found the right lower part of the abdominal wall involved more frequently than any other portion of the abdomen.

Various authors<sup>2,5-7</sup> give different occurrence rates. Approximately 90 per cent of the reported cases were in women and about 90 per cent of these women had borne children. Although the exact etiologic factor is unknown, Waugh<sup>9</sup> summarizes several observations which seem to indicate that these fibromas result from trauma with hemorrhage; and that the characteristics of a tumor are assumed during the

process of organization of the hematoma. The following observations bear this out: (1) frequent history of trauma to the region; (2) the tumors have occurred in the scars of previous incisions and (3) they are most common among women who have been pregnant.

*Pathology.* The desmoids are densely hard and cut with a grating sound. The cut surface reveals interlacing bands of fibrous tissue. The larger tumors tend to be soft in the center and some are actually cystic. Although Straub<sup>10</sup> reports changes in the overlying skin and keloid formation, this is distinctly unusual.

Microscopically, the appearance is that of a cellular fibroma occurring in striated muscle. Ewing<sup>3</sup> states that not infrequently the structure resembles a neurofibroma and varies from a hard, acellular fibroma to a rather cellular fibrosarcoma. Generally speaking, desmoids are not malignant and, while prone to local recurrence, do not metastasize. Sarcomas should not be included in this group.

The center of the tumor is older than the peripheral portion. At the periphery the tumor frequently infiltrates the surrounding muscle. Waugh and others state that there is no capsule or definite line of cleavage between the tumor and the adjacent muscle. When the tumor is adjacent to a fascial plane, an appearance of encapsulation may result.

The inclusion of striated muscle fibers is an unusual feature of the tumor. From the practical surgical standpoint it is undoubtedly easy to leave infiltrating portions



FIG. 1. Gross appearance of desmoid tumor of right rectus muscle.

of the tumor in the surrounding musculature. Pearman and Mayo's<sup>5</sup> recent study has shown that these tumors are definitely benign and that "recurrences" are actually the result of incomplete removal. They found that patients with these "recurrences," when subsequently undergoing complete excision, were cured for years.

*History and Examination.* Usually the patient finds a small, hard lump in the lower abdominal wall or she may have been totally unaware of the mass which is discovered during the course of a routine physical examination. When the mass gets larger, it may be visible (Smith<sup>4</sup>) or may produce a dragging sensation and occasionally actual pain due to the weight of the tumor. Walters and Church<sup>11</sup> found that only one-fourth of the patients in their series complained of pain or soreness.

Examination reveals a mass fixed in the abdominal wall which does not move with respiration. The mass can be moved to a slight degree with the abdominal muscles relaxed. With these muscles tensed, however, the tumor is completely immovable. The tumor may seem more superficial than the usual intraperitoneal mass. It is not attached to the skin, thus distinguishing it from a keloid.

*Treatment.* The treatment is wide surgical excision. Radiotherapy alone has not

been successful in curing these tumors but may be used as a supplement to surgery. This is particularly desirable when complete removal of the tumor is impossible. Removal of large tumors may leave a defect in the abdominal wall that is difficult to close and which may require fascial transplants

#### CASE REPORTS

The following patients on whom we operated present some interesting features.

**CASE 1.** The patient was a thirty-six year old white female who complained of pain in the right side of her abdomen of approximately two weeks' duration. The past history revealed that she was married for eleven years and had two children. One child was nine years old and the second child was two. The remainder of the past history was irrelevant.

About two weeks before seeking medical advice the patient noticed the gradual onset of an aching type of pain in the right side of the abdomen. The pain was continuous and did not radiate. It was more severe in the right upper quadrant than in the right lower quadrant. There was no history of indigestion or selective dyspepsia and the pain was unaffected by food intake.

Examination revealed a short, stocky woman weighing 220 pounds. The abdomen was very obese. A globular, firm, tender mass 6 to 8 cm. in diameter was palpable in the right upper quadrant. Although there was moderate splinting of the abdomen on the right side, the liver edge could be felt about two fingers below the costal margin. Tenderness made deep palpation of the mass difficult. The mass descended slightly with respiration. The blood count was as follows: red blood cells, 4,900,000; hemoglobin, 13 Gm., 82 per cent; white blood cells, 12,800; neutrophils, 70; segmented polymorphonuclears, 65; stab cells, 5; lymphocytes, 22; monocytes, 6; basophiles 2; shift to the left.

Although the mass was more medial and firmer than usual, before x-rays were taken a tentative diagnosis of hydrops or carcinoma of the gallbladder was made. The patient was hospitalized. Temperature on admission was 99°F., pulse 80. Cholecystography revealed a normally functioning gallbladder without stones. Urine examination showed a trace of albumin.



FIG. 2. High power magnification showing transformation from normal aponeurosis on the right to interlacing bundles of desmoid tumor on the left.

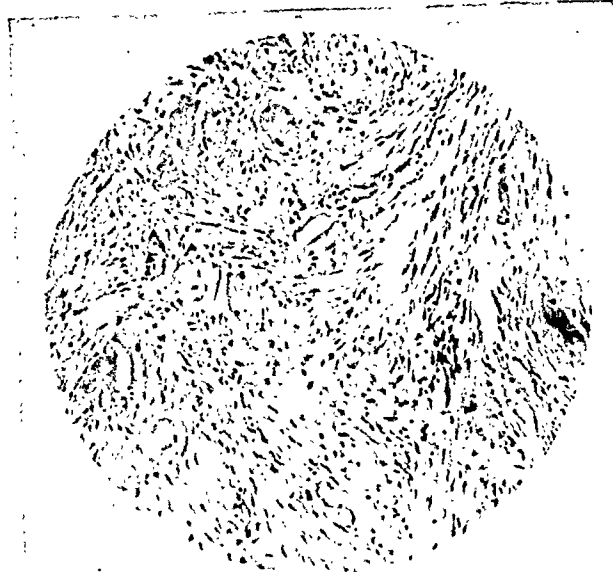


FIG. 3. Photomicrograph of edge of desmoid tumor showing invasion of rectus muscle.

In view of the negative x-ray findings, exploratory operation was decided upon in order to determine the exact nature of the mass. At operation after going through a panniculus adiposus of about 10 cm. in depth, the tumor was finally encountered. It had completely replaced the rectus muscle for about 6 to 8 cm. A wide excision was done and it was necessary to remove portions of the anterior and posterior rectus sheaths as well as the muscle. The peritoneum was opened and the liver was seen to descend below the costal margin. The gall-bladder and remaining viscera were normal. The appendix was removed and the defect in the abdominal wall was closed longitudinally in layers with some difficulty using interrupted silk sutures.

The pathologist reported that the growth removed was a desmoid tumor of the abdominal wall measuring 8 by 5 by 5 cm. Figure 1 shows the gross appearance of the tumor. Figure 2 shows a photomicrograph of the edge of the desmoid tumor showing the transition from normal fascia into interlacing bundles of desmoid tumor.

Convalescence was uneventful. The patient was out of bed the day after surgery and went home on the sixth postoperative day.

CASE II. M. M. a twenty-seven year old  
December, 1949

white female was admitted to the Alexander Blain Hospital, Detroit, Mich. She had noticed a lump in her lower abdomen on the right side six months before admission. Her past history revealed that she had been married five years before and had had one delivery. One year previously she had a uterine suspension done elsewhere through a midline suprapubic incision. The tumor had grown gradually larger during the past few months.

Examination revealed the uterus enlarged to the size of a seven-month pregnancy. There was an irregular, nodular, painless mass measuring 2 by 7 cm. present above the inguinal ligament just to the right of the midline. The skin was movable over the mass. The blood count and urine examinations were normal.

The patient was operated upon with a pre-operative diagnosis of tumor of the abdominal wall, possibly malignant. A 6 inch incision was made and the tumor was widely excised including generous portions of the involved fascia. A classical cesarian section was then done. Due to the large defect the abdominal wall was closed with some difficulty. The pathologist described a desmoid tumor measuring 10 by 4 by 4 cm. (Fig. 3.)

The patient's postoperative course was uneventful.

Eighteen months and eight months, respectively, since the dates of surgery both wounds were well healed without any sign of recurrence or hernia.

## COMMENT

Whereas most cases of desmoid tumors are painless, it is interesting to note that the first patient had pain and tenderness. The physical signs simulated a hydrops or carcinoma of the gallbladder or an inflamed gallbladder with omentum wrapped around it. The difficulty of differentiating an intraperitoneal mass from a mass in the depths of the abdominal wall by physical examination was insurmountable due to the patient's obesity. At operation the mass was seen to be about 10 cm. below the level of the skin whereas the gallbladder was in direct contact with the deep surface of the tumor.

The second case is of interest for two reasons. A malignant-appearing tumor proved to be benign and was cured by complete radical excision. Cesarean section could be done at the same time.

## SUMMARY

Desmoid tumors are frequently preceded by some form of trauma. These tumors are

benign and will not recur if excised widely. A case is reported which simulated hydrops of the gallbladder and another which simulated malignant tumor of the abdominal wall.

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# CONGENITAL ATRESIA OF THE COMMON BILE DUCT\*

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CONGENITAL atresia of the extra-hepatic bile ducts has held the particular interest of surgeons since Holmes in 1916 estimated that 16 per cent of the cases reported up to that time were theoretically amenable to surgical therapy. He suggested the establishment of an anastomosis or, if this could not be done, the establishment of an external biliary fistula and later the construction of continuity with the intestinal tract. However, it was not until 1935 when Ladd<sup>1</sup> reported a case in which the patient was successfully treated that this condition was satisfactorily handled. Since that time there have been additional reports of successful surgery<sup>2-11</sup> but not as many as one would expect. In October, 1948, Gray, DuShane and Henegar<sup>2</sup> reported two cases from the Mayo Clinic and could find only fifteen additional cases reported in the English literature. These fifteen included nine individual case reports and six cases reported previously by Ladd and Gross.<sup>3</sup> Also in October, 1948, Leyva and Madigan<sup>11</sup> reported five successful cases from the Children's Hospital of Washington. One of these had apparently been previously reported by Stiegler in 1946<sup>7</sup> and was included in the fifteen mentioned by Gray and his associates. Additional search through the literature has revealed no other cases in which the patient survived for any length of time and these twenty-one cases remain as the only completely successful ones reported.

Chesterman<sup>12</sup> reported a case of atresia of the common duct treated by cholecystoduodenostomy in which the patient died on the ninth postoperative day following a wound separation. Autopsy showed an intact anastomosis. Also, there have been

reported cases in which an obstruction due to inspissated bile was relieved by surgery,<sup>9,13,14</sup> the thick bile apparently being on the basis of Rh incompatibility.

Analysis of the twenty-one reported cases reveals that the gallbladder was anastomosed to either the stomach or small bowel in the majority of cases. The procedures used are as follows: cholecystogastrostomy eight, cholecystoduodenostomy six, cholecystojejunostomy one, choledochoduodenostomy three and hepaticoduodenostomy three.

## CASE REPORT

A. E., a Chinese-American boy, aged two weeks, was one of twins born in the Reading Hospital on June 18, 1948. It was the mother's first pregnancy and both children seemed normal at birth following an uncomplicated labor. The baby's birth weight was 5 pounds, 4½ ounces. It was noted that the child had the usual amount of "physiologic" jaundice which seemed to lessen about the eighth or ninth day. On the tenth day he was discharged from the hospital but was readmitted the following day because of the development of extreme jaundice and dehydration. The baby's temperature was normal. The abdomen was distended and the liver edge palpable two and a half fingers below the costal margin. There had been no vomiting. The stools were yellowish and the urine dark. The baby's weight was 4 pounds, 15 ounces. Blood count showed hemoglobin 79 per cent, red blood cells 3,800,000 and white blood cells 10,500.

On the twelfth day the weight was 4 pounds, 9 ounces; icterus index was 150 and the serum bilirubin 6 mg. The van den Bergh test showed a delayed direct reaction; the child was Rh positive. He was maintained on 2½ per cent glucose in normal saline, vitamin K and skimmed milk formula, and was admitted to Temple University Hospital on July 2nd, the fourteenth day of life.

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On admission to this hospital the child was extremely jaundiced and dehydrated. There was moderate apathy and skin turgor was poor. The only other positive finding on physical examination was that the liver edge was palpable 4 cm. below the costal margin. The spleen was not palpable and the child's temperature was 98.4°F. per rectum.

A stool on the day of admission was noted as being large, mucoid and pale yellow. Laboratory studies were as follows: hemoglobin 8.7 Gm., red blood cells, 2,710,000, white blood cells 9,200, polymorphonuclears 73 per cent, lymphocytes 20 per cent and monocytes 7 per cent. Coagulation time was four minutes and bleeding time thirty minutes. Urinalysis showed yellow color, no sediment, pH 6.0, negative for albumin, sugar, bile and occult blood. Microscopic study of the urinary sediment showed only 2 to 3 white blood cells per high power field. The blood Wassermann test was negative and the icterus index was 171 units. The van den Bergh direct reaction was very strongly positive and the indirect reaction showed 15.3 mg. per 100 cc. Blood cultures were repeatedly negative.

The child was maintained on a high protein formula with vitamin supplements and was given 10 mg. of vitamin K parenterally daily. On July 3, 1948, he was given 50 cc. of blood; bleeding time was one minute on this date. On July 9th examination of the urine showed a slightly positive reaction for bile pigments and a negative reaction for urobilinogen. The feces were negative for urobilinogen. Blood count showed hemoglobin 11.9 Gm., red blood cells 3,179,000 and white blood cells 18,300, with polymorphonuclears 40 per cent, lymphocytes 45 per cent, monocytes 8 per cent and eosinophiles 6 per cent.

A tentative diagnosis of congenital atresia of the bile ducts was made and the child was prepared for exploration. During this time penicillin was given (10,000 units every three hours from July 2nd to July 8th and 40,000 units every twelve hours from July 9th to July 21st, eight days postoperatively).

Abdominal exploration was done under local anesthesia on July 13th. The liver was somewhat congested. A normal gallbladder was observed; it was distended with dark, sticky bile. The common duct was present and large, and obviously extended down past the insertion of the cystic duct. The common duct

was not explored due to the poor general condition of the child. Cholecystojejunostomy was done and the abdomen closed as quickly as possible. During and immediately following the operation 100 cc. of blood were given intravenously.

Postoperatively the child made a satisfactory recovery. Gastric suction was maintained for twenty-four hours and then oral and gavage feedings were begun.

On July 15th, the second postoperative day, the child's temperature was 99.4°F. per rectum and it was noted that a stool showed mixed brownish and yellow color. A blood count showed hemoglobin 13.2 Gm., red blood cells 4,169,000 and white blood cells 9,200; the differential was normal. On July 16th the urine was negative for urobilinogens and on the seventeenth the icterus index had fallen to 86.

During this period the child had a tendency to lose weight but subcutaneous amigans seemed to enable him to begin gaining. On July 23rd the feces were found to be moderately positive for urobilinogen and on this day the skin sutures were removed.

By July 26th the icterus index had fallen to 20.5 units, the van den Bergh direct was slightly positive and the indirect 0.7 mg. per 100 cc. By the thirtieth the wound was well healed.

On August 2nd hemoglobin was 11.5 Gm., red blood cells 4,480,000 and white blood cells 18,400, with a normal differential. By the fifth the icterus index was 19 units, the van den Bergh direct was still moderately positive and the indirect was 0.6 mg. per 100 cc.

On August 12th the child was discharged from the hospital in good condition. Since that time he has been followed up in our Pediatric Clinic. On his last visit to the clinic in October, 1948, four months after operation, he was entirely normal.

#### COMMENT

Our purpose in presenting this case report is to emphasize the fact that although most children with this condition have proven to be inoperable on exploration, there is a definite salvage; and such patients must be carefully explored before we label them with a hopeless prognosis. When such patients appear to be operable, the simplest possible method should be employed due to the associated debility of the patient.

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# BILATERAL SIMULTANEOUS TUBAL PREGNANCY\*

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PREVIOUS to 1883 when Lawson Tait<sup>1</sup> of Birmingham, England, operated successfully for a ruptured tubal pregnancy, extrauterine gestation was of interest only from a pathologic view; but through his forceful writings a new impetus was given to its diagnosis and treatment. It should be remembered, as Mr. Tait points out, that the first authoritative treatise on extrauterine pregnancy was written by John S. Parry, an American, in 1876; and antedating Parry, John Bard<sup>2</sup> of New Jersey published a report of three laparotomies for extrauterine pregnancy in 1759. This was followed by the report of William Baynham<sup>3</sup> of Virginia on his two successful operations in 1790 and 1799.

Since Tait published his observations, the literature on extrauterine pregnancy has become so voluminous that a complete review would prove practically impossible.

The occurrence of bilateral simultaneous tubal pregnancy, however, is so infrequent that many texts either omit its discussion or give a short reference to the condition. We believe that an additional report is worthy of record.

The following classification of extrauterine gestation admits of proper grouping: (1) intrauterine pregnancy combined with extrauterine pregnancy; (2) intraperitoneal (abdominal) gestation; (3) multiple pregnancy in a single fallopian tube and (4) coincident pregnancy in each fallopian tube.

The reports of bilateral simultaneous tubal pregnancy have been conspicuous not only because of rarity but also because of the incompleteness of data in some few published reports, so much so, that one is confronted with difficulty in arriving at a correct diagnosis and definite conclusion.<sup>4</sup>

Fishback<sup>5</sup> has published an illuminating résumé of the literature on bilateral tubal pregnancy with emphasis on classification accompanied by a report on multiple tubal pregnancies in which he also found insufficient data in many to be acceptable for definite classification.

Schockaert<sup>6</sup> in 1928 collected from the literature only eighteen cases of simultaneous bilateral tubal pregnancy. The number reported by different observers has varied and many different opinions are expressed regarding the criteria to be used in their classification.

Many explanations have been advanced as to etiology, some plausible others fantastic. Kelly and Noble's<sup>7</sup> summation as to favorable factors seem all inclusive: (1) conditions which interfere mechanically with the downward passage of the ovum and (2) physical and developmental conditions which favor decidual formation in the tubes.

In a search of the literature only eighty-seven reported bilateral simultaneous tubal pregnancies were found to admit of a positive grouping and in only thirty-four could one be positive as to simultaneous conception.

Proust<sup>8</sup> is of the opinion that in practice the diagnosis of bilateral tubal pregnancy is never made preoperatively and most surgeons, I am confident, are in perfect agreement.

## CASE REPORT

D. A. Y., a white, married female, aged thirty-four, was hospitalized on September 5, 1947, complaining of abdominal pain and distention. She was the mother of a healthy child of fifteen. A history of five spontaneous

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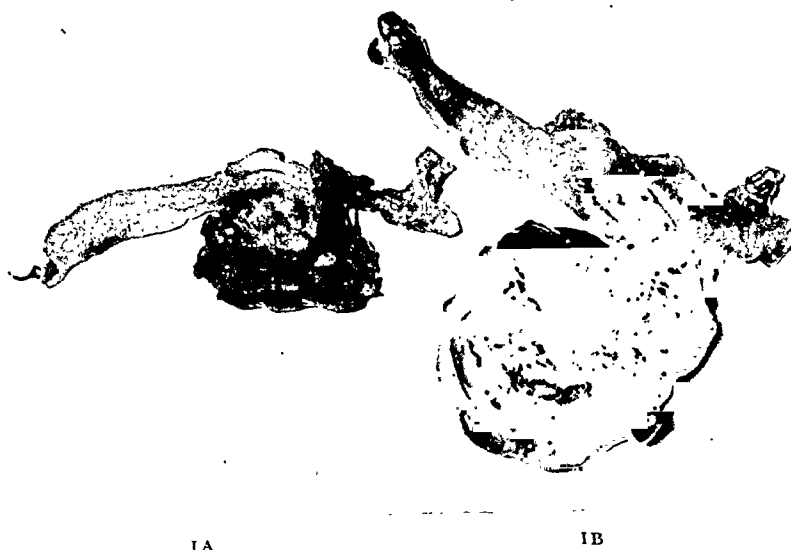


FIG. 1. Bilateral tubal pregnancy; A, left tube; B, right tube.

miscarriages in the second month during the past fourteen years was obtained. Menstruation began at the age of twelve and was of four or five days' duration, with slight pain; it has been of the thirty-day type. Her last menses occurred in the early days of July, 1947, accompanied with no unusual symptoms.

On September 2, 1947, while at work as a bookkeeper she experienced a full feeling in the lower right quadrant followed by a sharp pain after which she became faint. Upon reclining for a short while she felt better and resumed her work for about thirty minutes. Intermittent fainting ensued accompanied with a bloody vaginal discharge necessitating her return home where she resorted to sedatives and enemas for three days. However, because of increasing distention, dysuria and pain, her physician was summoned; he immediately sent her to the hospital.

Physical examination revealed a well developed, white female weighing 126 pounds. Her blood pressure was 100/68, pulse 130, temperature 99°F. and respiration 26. The abdomen was quite distended and tense; the umbilicus was rather prominent with a circumscribed area of bluish discoloration (Cullen's sign). Increased rigidity over both lower quadrants was present with dullness over flanks. Vaginal examination disclosed a bloody discharge. On movement of the cervix severe pain was experienced. A doughy, crepitant mass was palpated in the pouch of Douglas which was continuous with bulging in the right

adnexal region; no mass was found in the left adnexal region.

Laboratory findings were as follows: red blood cells, 3,000,000; hemoglobin (8.5 Gm.), 50.4 per cent; color index, .81; 10,000; lymphocytes, 20; monocytes, 2; neutrophils, 76 and eosinophiles, 2. The urine revealed no unusual findings; the Kahn test was negative.

A diagnosis of ruptured right tubal pregnancy was charted and an immediate abdominal section was performed.

Spinal anesthesia and sodium pentothal were used. On incising the peritoneum a gush of bright red blood ensued. A large mass of clots filled the pelvis and on delivery of the right fallopian tube a rupture in the distal third was found with attached blood clot and tissue. Slight active bleeding was present. The left oviduct was found to be engorged, with a dilated distal portion containing an embryo surrounded by a lobular brown mass which ruptured as a result of operative manipulation.

Bilateral salpingectomy was instituted followed by a transfusion of 500 cc. of blood; auto-transfusion was not thought advisable.

The pathologic report (supplied by Dr. E. W. Townsend) was as follows: The specimens consisted of both fallopian tubes. (Fig. 1.) The left tubo-ovarian mass, located at the distal end of the fallopian tube, was dilated and measured 40 mm. in diameter. It was open on one surface and presented a reddish brown color. The open surface had a lobular appearance. In the center of this mass and attached to it was a fetus

measuring 10 mm. in length. The oviduct varied in diameter from 3 to 10 mm. Blocks for microscopic sections were taken just proximal to the mass described, the distal portion of the ruptured fallopian tube with fetus being preserved as a gross specimen.

The microscopic sections showed a hemorrhagic infiltration of the wall of the fallopian tube associated with the presence of masses of fibrin and blood cells within which there were degenerative changes and deposition of hemosiderin.

The second specimen consisted of the right tubal mass and of a clot of blood and tissue measuring 65 mm. in its greatest diameter. The tubal mass measured 130 mm. in length and varied from 8 to 30 mm. in diameter. In the distal third of the oviduct there was a rupture and an expanded portion which measured 35 mm. in diameter. No fetus was grossly identified in this specimen of the right tube and accompanying tissue.

The microscopic sections of the right tubal tissue and blood clot showed numerous cross-sections of chorionic villi and masses of syncytial cells mingled with portions of the fimbriated end of the fallopian tube in which hypertrophic changes, congestion and edema were notable.

The diagnosis was bilateral tubal pregnancy.

The patient was discharged on the twelfth postoperative day.

#### SUMMARY

A bilateral tubal pregnancy is reported with rupture and intraperitoneal hemorrhage from one oviduct coexistent with an unruptured pregnancy in the opposite oviduct.

As to superfecundation or superfetation in relation to the reported case, this we pass on to the more speculative.

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# REACTIONS FOLLOWING INJECTION OF VARICOSE VEINS

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THE proper use of sclerosing agents unquestionably has value in the treatment of varicose veins. It must be remembered that the sclerosing agent destroys the endothelial lining of the vein initiating the formation of an adherent clot. It causes in effect a localized, controlled chemical thrombophlebitis which is accompanied by a variable degree of increased vascular irritability and spasm.

Successful sclerosis depends upon proper selection of cases, proper technic and adequate postoperative care. These factors have been discussed in a previous communication.<sup>1</sup> If a vein is to be permanently obliterated, the amount of clot must be held to a minimum and the vein kept collapsed until healing has taken place. This requires prolonged wearing of elastic bandages or stockings and is true whether ordinary office injections or operative retrograde sclerosis are contemplated. I believe that many unsatisfactory results have been due to neglect of this disagreeable phase of the treatment.

It is observed that with proper selection of cases most of the abnormal reactions to sclerosing agents can be avoided. Thus no serious reactions have occurred in the past two years in the course of treating a considerable number of patients.

*Allergic Reactions.* Some people are sensitive to the ordinary sclerosing solutions. These include sodium morrhuate, sodium ricinoleate and ethylaminoleate. Those patients exhibiting other allergies such as hay fever, asthma and hives should always be suspected and sensitivity tests made.

## CASE REPORTS

CASE 1. A. K., age forty-seven was admitted to the New York Post-Graduate Hospital, J94896. The diagnosis was bilateral varicose veins and varicose ulcer of the left

ankle. The patient suffered from hay fever and asthma. She was sensitive to ordinary adhesive tape and tests showed allergy to sodium morrhuate and sodium ricinoleate in test doses of 0.2 cc. intravenously. Bilateral saphenous ligation was performed on July 21, 1945, without retrograde sclerosis. Subsequent injection with quinine and urethane was successful. The ulcer has remained closed to date.

*Comment.* A probable catastrophe was avoided by preliminary sensitivity tests. Patients who have had injection therapy in the past sometimes acquire sensitivity. In these cases a test dose of 0.2 cc. of the sclerosing solution is injected before treatment is begun.

CASE 11. A. M., age forty-nine, was admitted to the Midtown Hospital, D-881. The diagnosis was bilateral varicose veins, duration twenty-eight years, with edema and ulceration of right leg.

A left saphenous ligation was performed on September 19, 1944, and retrograde sclerosis with 3.0 cc. sodium morrhuate was carried out. On September 20, 1944, a right saphenous ligation was done; retrograde sclerosis with 4.0 cc. sodium morrhuate was done. She had an uneventful postoperative course. Her maximum temperature was 100.8°F. Five weeks later two residual varices were injected each with 1.0 cc. sodium morrhuate. Two hours later generalized urticaria and mild asthma developed. Subsequently the patient was tested with small doses of sodium ricinoleate and of ethylamineoleate and similar sclerosing solutions but milder reactions took place. No further sclerosis was attempted.

*Comment.* This acquired sensitivity must be anticipated when a long period is allowed to elapse between injections. In my experience this is the earliest appearance of an acquired sensitivity. I have never had any difficulty with injections

made three to four weeks following retrograde sclerosis.

*Reactions Due to Pyrogens.* Retrograde sclerosis is performed with a ureteral catheter. If any blood is allowed to remain within, it may cause a foreign protein reaction. In addition broken down blood is an excellent culture medium for bacteria. A case has come to my attention in which a sharp chill and a transient *Bacillus coli* bacteremia followed retrograde sclerosis. Cultures taken from washings of the catheter grew *B. coli*.

*Reactions Due to Improper Dosage.* At the present time relatively small doses of sclerosing agent are used with the retrograde technic. I never use more than 5 cc. on one side and never sclerose more than one side at a time. If too much is injected, the solution puddles and may actually erode the vessel wall causing a sterile abscess. Excessive dosage may also result in pigmented spots or streaks to a greater degree than necessary. It also causes unnecessary pain and fever.

There is a great variation in the reactivity of these patients to their medication which can only be determined by observing the test reaction. It is better to inject an inadequate dose than to bring about an uncomfortable or alarming situation by injecting too much.

*Reactions in the Presence of Vascular Disease.* Patients with clinical vascular disease should have no sclerosis under any circumstance. Most of these patients have highly irritable vascular systems and sclerosis increases the vasospastic element. In this group I would include patients with thrombophlebitis, Raynaud's disease, Buerger's disease and all those giving symptoms of vascular irritability such as cold, clammy extremities with painful, abnormal response to cold. Sclerosis should never be attempted in the presence of obliterative arterial disease. The added spasm may reduce the caliber of the involved vessels or their collateral bed to a critical degree resulting in gangrene.

CASE III. Y. B., age thirty-five was admitted to the New York Post-Graduate Hospital, J86875. The diagnosis was right femoral thrombophlebitis with ulceration of ankle and bilateral varicose veins. For eight years the patient had had recurrent attacks of phlebitis in her right leg, the first attack occurring during pregnancy. Ulceration on the medial aspect of the right ankle had been present for one year. Bilateral varicose veins were present and were more advanced on the right side. The patient was admitted July 5, 1943, for preliminary elevation and soaks. Sedimentation rate was 35 mm. per hour.

A left saphenous ligation was performed on July 12, 1943, with retrograde sclerosis. A catheter was introduced 35 cm. and 12.0 cc. sodium ricinoleate were injected as the catheter was withdrawn. The next day her temperature rose abruptly to 104.4°F. The left leg became hot and the sclerosed vessels tender. There was no gross edema. Hot packs were applied and the temperature returned to normal in ten days. On July 28, 1943, a right saphenous ligation without sclerosis was performed. The course was uneventful. Subsequently she developed signs of vasospasm and one year later two bilateral paravertebral novocain nerve blocks were performed with considerable benefit.

*Comment.* No sclerosis should have been done in this case. It undoubtedly caused the alarming temperature response besides aggravating later vasospastic phenomena, nor would we now use as much sclerosing solution under any circumstance. Another case was observed in which a saphenous ligation with retrograde sclerosis had been performed two years following an acute femoral thrombophlebitis. Here no marked reaction occurred but for six months there was increased edema, pain and skin moisture all indicative of vasospasm.

CASE IV. E. T. age thirty-seven, was admitted to the Midtown Hospital, C-10648. The diagnosis was bilateral varicose veins and recurrent superficial phlebitis of right leg. For eight years this patient had had episodes, recurring once or twice yearly, of swelling, redness and pain of the right leg. The onset of these attacks was sudden and accompanied by

chills and fever. They yielded promptly to conservative therapy including bed rest, hot packs and sulfonamides. In between attacks the legs swelled on prolonged standing and she noticed progressive enlargement of the veins. Sedimentation rate was 8 mm. per hour.

On June 5, 1944, a left saphenous ligation was done. Retrograde sclerosis was accomplished with 4.0 cc. sodium morrhuate. Two days later she experienced a sudden chill and her temperature rose to 104.2°F. The right leg became swollen, red and painful. Hot packs and sulfadiazine promptly cleared the situation. On June 9, 1944, the patient's temperature became normal. About three weeks later she was readmitted and a right saphenous ligation was done without retrograde sclerosis. Her postoperative course was completely uneventful.

*Comment.* I believe reactivation of the superficial thrombophlebitis was precipitated by reflex vasospasm induced by sclerosis of veins in the opposite leg.

CASE V. A. E., age forty-six, was admitted to the New York Post-Graduate Hospital, J85700. The diagnosis was bilateral varicose veins and atypical Raynaud's disease of the upper extremities.

On June 20 and 22, 1944, bilateral saphenous ligation with retrograde sclerosis was performed. The postoperative course was characterized by massive sclerosis of both greater saphenous systems, pain and temperature to 103.8°F.

*Comment.* Although the result as far as the varicosities was concerned was excellent, this patient's Raynaud-like syndrome became worse during the following year. It was undoubtedly aggravated by the use of sclerosing agents. I believe no sclerosis of any sort should be attempted in this type of patient.

CASE VI. H. K., age twenty-nine, was admitted to the New York Post-Graduate Hospital, J88121. The diagnosis was bilateral varicose veins. These veins had been noticed nine years previously following birth of a

child. There was no history suggesting phlebitis. For three years there had been considerable pain with edema of the legs on prolonged standing. She was extremely nervous and apprehensive. The extremities were moist and cold.

On October 20, 1944, a left saphenous ligation with retrograde ligation was performed. A catheter was introduced 50 cm. and 3 cc. of sodium ricinoleate were injected. The following day a similar procedure was carried out on the right side. The afternoon following the second operation the patient's temperature rose to 105°F. and the next day rose to 107.4°F. Massive bilateral sclerosis of the entire greater saphenous systems took place. There was no evidence of femoral thrombophlebitis. Conservative measures including the use of papaverine were instituted and six days later her temperature returned to normal. She was discharged on the ninth postoperative day.

*Comment.* Although the contraindications to retrograde sclerosis in this case were not too clear-cut, it is believed more attention should have been paid to the signs of heightened vascular irritability. Incidentally, an excellent result was obtained.

Homans<sup>2</sup> postulates that some reactions following sclerosis are due to femoral thrombophlebitis. I have not been aware that this is so and believe that immediate and frequent ambulation prevents this serious complication.

#### SUMMARY

The problem of abnormal reactions following the use of sclerosing agents in the treatment of varicose veins is discussed. Various types of reactions are discussed and illustrative cases are presented.

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# HYPERTENSION COMPLICATED BY SPONTANEOUS SUBARACHNOID HEMORRHAGE\*

## A PLAN OF MANAGEMENT

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IN recent years a significant change has occurred in the method<sup>7</sup> of managing spontaneous subarachnoid hemorrhage. Formerly the emphasis in treatment was entirely on bedrest and supportive measures. After recovered patients had been followed-up for periods of time, it became evident that recurrences of hemorrhage were common and mortality increased with recurrence. Pathologic studies called attention to the existence of ruptured intracranial arterial aneurysm as the lesion very frequently the cause of subarachnoid hemorrhage. The background was thus supplied for the pioneer work of Dandy<sup>1</sup> who then began to treat these patients with a direct surgical approach in the attempt to cure the patient of the aneurysm. Surgery now has a proper place in the management of subarachnoid hemorrhage.

As interest in spontaneous subarachnoid hemorrhage grew, it became apparent that this type of cerebrovascular accident was frequently associated with arterial hypertension. Hirschfeld, Tornay and Yaskin<sup>2</sup> found high blood pressure in 66 per cent of their series of fifty patients. In other reports of collected cases the incidence of hypertension was substantial but not as great.

It was also found that the presence of hypertension increased the mortality from subarachnoid hemorrhage. In Dandy's large series of ruptured intracranial aneu-

rysms there were twenty-five patients with hypertension; all twenty-five died. In a review of the literature Forrest<sup>3</sup> collected 168 cases; in only two instances did persons with systolic blood pressure above 200 mm. survive an episode of spontaneous subarachnoid hemorrhage.

Since hypertension adds to the gravity of the prognosis for these patients, it is reasonable to emphasize this factor in any plan for long range management of such cases. For a number of years we have been impressed with the significant reductions in blood pressure maintained by hypertensive patients who have been treated with the operative procedure of bilateral supradiaphragmatic splanchnicectomy. Among the many cases of essential hypertension in which patients were treated with this operation at the University of Michigan Hospital, there were seven patients who had previously sustained a definite subarachnoid hemorrhage. The subsequent course of these seven patients forms the basis for this report which recommends the use of splanchnicectomy in a plan of treatment for hypertensive persons who sustain a subarachnoid hemorrhage.

### SURGICAL ISOLATION OF INTRACRANIAL ANEURYSMS

Subarachnoid hemorrhage of non-traumatic origin may be the result of several conditions, namely, a ruptured intracranial

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arterial aneurysm, extension from a massive intracerebral hemorrhage, meningeal inflammation, bleeding from a neoplasm or a blood dyscrasia. But a ruptured intracranial aneurysm is by far the most common cause. In the large series of Richardson and Hyland<sup>4</sup> careful autopsies performed in fatal cases revealed ruptured arterial aneurysms present in 90 per cent; they thus believed they were justified in assuming that practically all their cases of spontaneous subarachnoid hemorrhage were due to aneurysm, including those patients who survived. Sahs and Keil<sup>6</sup> also have stated that intracranial aneurysms account for most of these cases.

Thus in most instances of spontaneous subarachnoid hemorrhage the cause is a pathologic lesion which can be isolated from the cerebral circulation by appropriate surgical methods. However, the existence of an aneurysm and its location should be clearly defined before a craniotomy is performed. Localizing clinical signs may occur in subarachnoid hemorrhage but the presence of localizing signs is no assurance that an arterial aneurysm will be found nor does it fix the exact site of the aneurysm if one is present.

*Intracranial Angiography.* Although there is a fixed clinical syndrome characterizing most aneurysms, precise localization and diagnostic confirmation of the aneurysm are obtained only by intracranial angiography. This procedure has been used extensively at the University of Michigan Hospital since 1941 to enable a precise diagnosis of vascular lesions.<sup>6-8</sup> The carotid arteriogram performed with 25 per cent thorotrast is utilized routinely on all patients in whom a ruptured intracranial aneurysm is suspected as soon as the acute phase of the clinical picture has subsided. It has been employed without danger to the patient; neither morbidity nor mortality attributable to the procedure has occurred in this hospital.

*Recurrence of Hemorrhage.* The absolute need for a surgical method of curing the patient of his intracranial aneurysm is

apparent from consideration of the significant recurrence rate of subarachnoid hemorrhage and of the high mortality of recurrences. In Hamby's<sup>9</sup> series there were thirty-two patients admitted in a secondary attack of bleeding; their mortality was 72 per cent. A second hemorrhage occurred in fifty of the 150 patients in Magee's<sup>10</sup> series; it should be pointed out that ninety-eight survived the primary episode. Fifty recurrences in ninety-eight possibilities constitutes a very high recurrence rate. There was a 64 per cent mortality among the fifty recurrences.

In the series of Wolf, Goodell and Wolff<sup>11</sup> there were forty-six patients; 52 per cent had recurrent attacks. The mortality in the twenty-four patients who had recurrent subarachnoid hemorrhages was 41.8 per cent. Wolf and associates combined their cases with those of Magee and found that of the seventy-four patients who had recurrences, forty-one happened in the second to fourth week; of the forty-two patients who died of recurrence, twenty-eight died during this period. They thus conclude "if patients with subarachnoid hemorrhage could be treated effectively and safely by surgical procedures in the first two weeks after the hemorrhage, the threat of recurrent hemorrhage and death in approximately 70 per cent of all patients with subarachnoid hemorrhage could be removed."

#### SPLANCHNICECTOMY PERFORMED SUBSEQUENT TO SUBARACHNOID HEMORRHAGE

Bilateral supradiaphragmatic splanchnicectomy has been performed on seven patients with essential hypertension in each of whom a spontaneous subarachnoid hemorrhage had occurred from two months to three years before sympathectomy. Each case has been followed up for long periods of time. The clinical data of these cases are summarized in Table 1. Each patient presented the characteristic clinical picture of subarachnoid hemorrhage, further confirmed by the spinal fluid findings. The



TABLE I  
CLINICAL DATA IN SEVEN CASES OF ESSENTIAL HYPERTENSION COMPLICATED BY SPONTANEOUS SUBARACHNOID HEMORRHAGE

Case	Age at Time of Hemorrhage	Sex	Symptoms	Neurologic Signs	Blood Pressure at Time of Hemorrhage	Spinal Fluid	Blood Pressure prior to Spinalnecotomy	Result			
								Living or Dead	Survival since Hemorrhage (yr.)	Survival since Spinalnecotomy (yr.)	Recent Blood Pressure
I J. W.	42	M	Severe headache of sudden onset; convulsions; projectile vomiting	Papilledema; nuchal rigidity; nystagmus; diminished reflexes	185/130	Xanthochromic pressure 160 mm.	150/120	L	14	13	152/98
II H. S.	36	F	Sudden onset of severe headache; blindness; delirium	Stiff neck; stupor	230/140	Bloody pressure 370 mm.	192/120	D	10	9	.....
III C. P.	46	M	Sudden onset of severe occipital headache; nausea; vomiting; right hemiparesis	Nuchal rigidity; positive Kernig	240/150	Bloody pressure 420 mm.	236/164	L	8	8	190/125
IV W. B.	37	M	Severe headache; diplopia; vertigo; nausea; vomiting	Papilledema; extraocular palsy; nystagmus; ataxia; nuchal rigidity; positive Kernig	240/130	Xanthochromic pressure 350 mm.	210/130	L	8	8	151/104
V I. B.	38	F	Sudden excruciating headache; nausea; vomiting; thick speech	Nuchal rigidity	185/115	Bloody pressure 220 mm.	195/118	L	10	7	184/112
VI F. R.	48	M	Sudden onset of severe headache; nausea; vomiting; generalized convulsion	Disoriented and confused; extraocular palsy; absent knee and arm jerks; nuchal rigidity; positive Kernig bilaterally	250/160	Bloody pressure 400 mm.	210/130	D	7	4	.....
VII M. B.	36	M	Sudden onset of severe occipital headache; nausea; vomiting	Coma; nuchal rigidity; internal and external ophthalmoplegia right eye; positive Kernig	160/102	Bloody pressure 450 mm.	178/116	L	3	2	136/88

episode of bleeding was treated in this hospital in three instances prior to the time that arteriography was included in our program of management. In three cases the initial hemorrhage was treated in other hospitals. A carotid arteriogram and subsequent craniotomy were performed in Case VII.

Case VII. M. B., age thirty-six, was admitted on May 9, 1945, complaining of severe headache and stiff neck. Three weeks previously he had noted sudden onset of severe headache and stiff neck. The following morning he noted that his right eyelid drooped and his neck was stiff. Headache, nausea and vomiting persisted at bedrest and two days prior to admission his wife found him comatose.

Physical examination on admission revealed a blood pressure of 160/102 and temperature of 99.2°F. orally. He was restless, confused and made many purposeless movements. There was complete internal and external ophthalmoplegia of the right eye. Nuchal rigidity was marked and Kernig's sign was positive bilaterally.

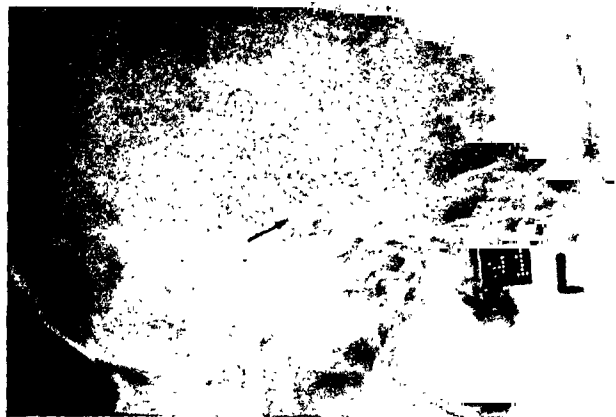
Lumbar puncture revealed bloody spinal fluid under pressure of 450 mm. of water; the red blood cell count of the fluid was 2,350,000 per cu. mm. With bedrest and mild sedation the patient gradually improved.

A right internal carotid arteriogram obtained on June 2, 1945, clearly defined an aneurysm arising from the proximal portion of the middle cerebral artery. (Figs. 1 and 2.)

Craniotomy was performed on June 4, 1945, by Dr. Carl F. List. The aneurysm, the size of a large pea, was found to arise from the beginning of the right middle cerebral artery. An anomalous, collateral blood supply to the right hemisphere was seen to come off the circle of Willis; this permitted ligation of the middle cerebral artery, thus isolating the aneurysm from the cerebral circulation. Postoperative convalescence was uneventful; no paresis developed, indicating that the anomalous, collateral blood supply to the right hemisphere was adequate.

During the following year there was progressive improvement of the ocular palsy. However, the patient's blood pressure persisted at elevated levels and averaged 178/116. He complained of frequent mild headaches and dizziness. The electrocardiogram was within normal limits and the teleoroentgenogram revealed

December, 1949



1



2

FIG. 1 and 2. Right internal carotid arteriograms demonstrating an aneurysm arising from proximal portion of the right middle cerebral artery in Case VII.

normal heart size. Intravenous pyelogram and urinalysis were negative, blood non-protein nitrogen was 37 mg. per cent, urea clearance values averaged 60 per cent and maximum specific gravity on an eighteen-hour concentration test was 1.021. Bilateral supradiaphragmatic splanchnicectomy and lower dorsal ganglionectomy (dorsal 9-12) were done May 9, 1946. The patient was discharged on the ninth postoperative day.

In September, 1948, two years after splanchnicectomy, he was completely asymptomatic. He was maintaining normal blood pressure

levels averaging 136/88 and was earning a livelihood as a truckdriver.

In each instance splanchnicectomy was performed both for the treatment of the patient's hypertensive disease in general and in the attempt to produce a lasting, significant reduction in blood pressure in order to lessen the likelihood of a recurrence of "blowout" of an intracranial aneurysm. High blood pressure undoubtedly was an important factor in the ultimate rupture in each case. Since the ages of these persons ranged from thirty-six to forty-eight years, it is logical to assume that hemorrhage resulted from rupture of a congenital aneurysm in each instance rather than from rupture of an arteriosclerotic vessel. The high mortality resulting from the association of hypertension and subarachnoid hemorrhage warrants an effort to correct the hypertensive state in those few patients fortunate enough to survive the primary hemorrhage. In Dandy's series there were four hypertensives who sustained recurrence of ruptured congenital aneurysms; all four died.

Five of our patients are still living and have had no recurrence, from two to thirteen years after the splanchnicectomy and from three to fourteen years after the subarachnoid hemorrhage. Four have maintained significant reductions of more than 20 mm. of diastolic pressure; the hypertensive levels of the fifth living patient have been uninfluenced by the sympathectomy. The patient in Case I has had frequent normal blood pressure determinations during the thirteen years since operation. Another patient, Case II, maintained a significant reduction of 25 mm. of diastolic pressure for nine years after splanchnicectomy and worked as a stenographer during this time. She then sustained a cerebrovascular accident and died three days later. Both deaths in this group occurred at home and autopsies were not obtained.

#### A PLAN OF MANAGEMENT

During the acute phase the patient is strictly confined to bed with his head

elevated. Therapy is entirely supportive. Sedation is utilized for restlessness and excitement, and analgesics for relief of headache. Fluid requirements are minimal; fluids should be given in amounts no greater than is necessary for adequate kidney function. Lumbar puncture is performed for diagnosis only, with 1 to 2 cc. of spinal fluid slowly withdrawn. Only on rare occasions is lumbar puncture used therapeutically in order to reduce dangerously increased intracranial pressure; spinal fluid is removed very slowly, drop by drop, until approximately half of the initial pressure is established.

After the acute phase has subsided, usually seven to fourteen days, or if there is evidence of persistent bleeding at bed-rest, carotid arteriography is performed. If the arteriogram reveals an aneurysm, the ensuing surgical approach will depend upon the location of the aneurysm: (1) Aneurysms of the intracranial portion of the internal carotid artery readily accessible to surgical isolation are those which are located sufficiently below the bifurcation of the internal carotid into the anterior and mid-cerebral arteries to permit trapping of the aneurysm between a ligature of this artery in the neck and another one placed just below the bifurcation. (2) Aneurysms arising from the anterior cerebral artery between the intracranial carotid bifurcation and the anterior communicating artery are isolated by clips placed proximal and distal to the origin of the aneurysm. (3) Aneurysms of the anterior communicating artery often are not amenable to surgical isolation for frequently both anterior cerebral arteries must be ligated in order to isolate such an aneurysm; this latter type of ligation usually results in massive softening of both frontal lobes. (4) Aneurysms of the mid-cerebral artery are attacked directly in the hope of preserving the major circulation to the ipsilateral hemisphere. Naturally, no attempt is made to isolate aneurysms of this artery from the cerebral circulation by ligation. Instead, strengthening of the aneurysmal wall is

sought through muscle packs or other hemostatic tampons. The various operative technics are fully elaborated in a publication by Bassett, List and Peet.<sup>12</sup>

Only by means of arteriographic studies can the indications for the foregoing surgical approaches be determined prior to craniotomy. If the arteriogram reveals no aneurysm, the patient should be confined to bedrest for at least four weeks after bleeding has ceased.

If the hypertensive patient presents himself for the first time following recovery from an episode of hemorrhage: (1) In the presence of persistent, localizing clinical signs and symptoms carotid arteriograms must be taken; and if an aneurysm is revealed, surgical treatment should proceed as outlined. (2) In the absence of localizing signs and symptoms arteriography may be considered optional. However, splachnicectomy is now recommended in the attempt to produce a persistent, significant reduction in blood pressure.

There is always the possibility that multiple aneurysms may be present; and since one of these may be 'blown out' as the result of persistent hypertension, the patient's essential hypertension should be treated with splachnicectomy.

#### SUMMARY

In consideration of the evidence that recurrences of spontaneous subarachnoid

hemorrhage are frequent, that mortality increases markedly with recurrence and that mortality is particularly great among those with an associated hypertension, a plan of management directed toward preventing death from recurrent episodes of hemorrhage in survivors of the primary attack has been presented.

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## THE YALE SCHOOL OF MEDICINE

THE initial organization of the School of Medicine was completed in 1812 following the passage of a bill by the Connecticut General Assembly in 1810 which granted a charter for "The Medical Institution of Yale College," to be conducted under the joint supervision of the College and the Connecticut State Medical Society. This institution was formally opened in 1813 and the first degrees were conferred the following year. In 1884, with the approval of the Medical Society, the original charter was amended to place the school definitely in the control of the College as the Medical School of Yale College. The name Yale College was changed to Yale University in 1887 and the name of the Medical School was automatically changed. The present name of the school was adopted in 1918.

The godfather of this medical school, whose graduates are found in every state and in many foreign lands, was Benjamin Silliman, sponsor of scientific education in America. He taught the first course in chemistry ever given to candidates for the M.D. degree. Dr. C. N. Hugh Long, one of the nation's leading physiological chemists, has assumed the deanship of the school.

A new Professorship of Oncology is now held by Dr. Samuel C. Harvey, surgeon, and brings together Yale's extensive research on the problems of cancer. This chair of Oncology, one of the first in America, has been made possible by grants from the U.S. Public Health Service and

from Mr. Robert Hunter of California. Yale's School of Medicine has been a center for the investigation of cancer problems for many years. At present more than two-thirds of the staff are attacking the cause and possible cure of cancer.

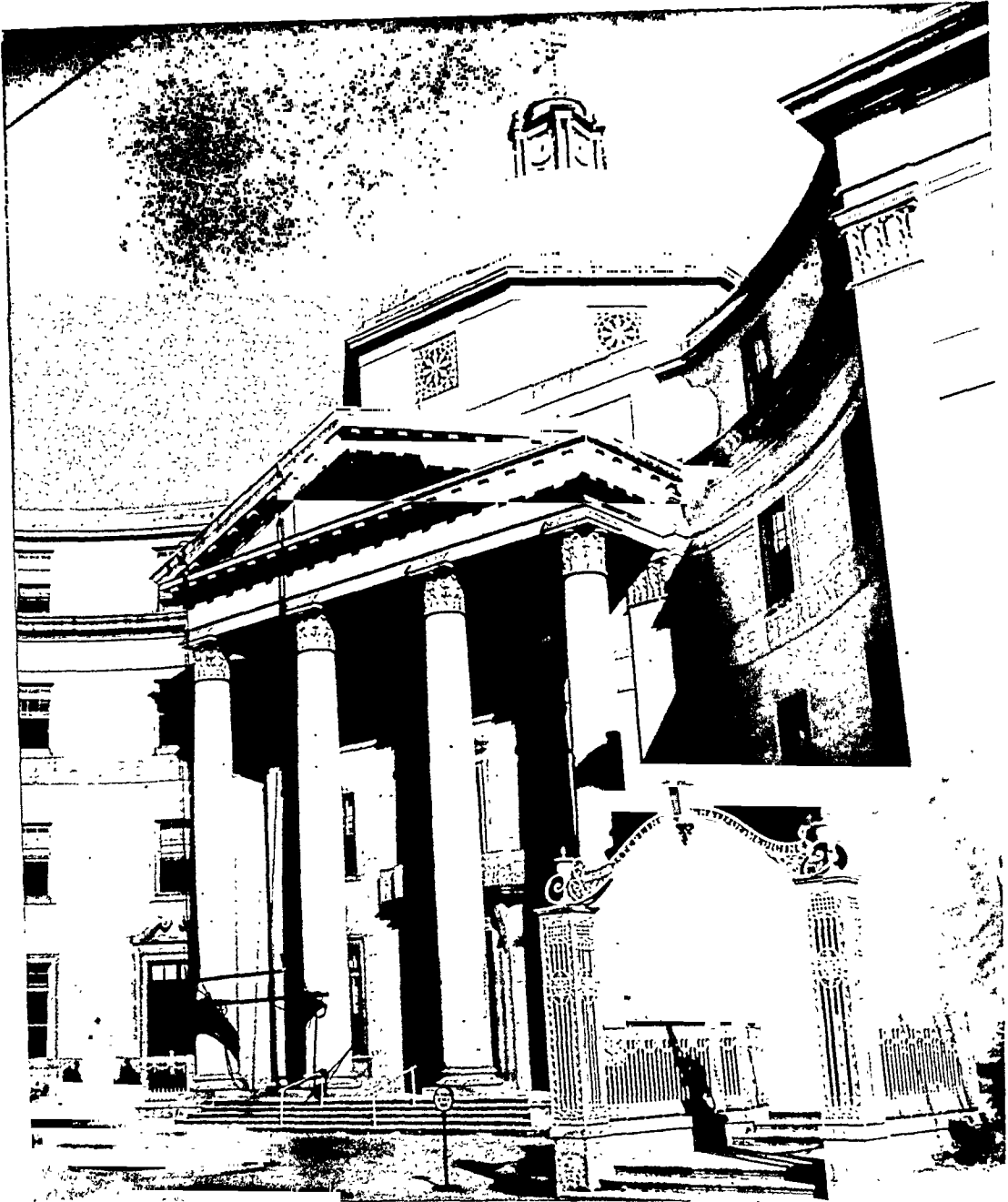
Yale's expanding interest in the field of post-graduate medical education is illustrated by a post-graduate seminar in psychiatry now being held in cooperation with state mental hospital staffs and the Connecticut State Medical Society.

In the same spirit of broader contacts between Yale and the community of which it is a part an Institute of Occupational Medicine has been developed as well as a series of courses in hospital administration which are sponsored by the Yale Department of Public Health in cooperation with the Grace-New Haven Community Hospital.

Yale's affiliations with other hospitals in Connecticut are being expanded in accordance with the general plan for increasing training opportunities and providing a broader pattern of service.

The Yale School of Medicine has long been known for the importance it places on its investigative work which remains one of the keystones of its educational policy.

The total enrollment for 1947-1948 in the Yale School of Medicine is 380. Graduates from 175 institutions are represented in this number. Students are enrolled from forty-five different states and from fourteen foreign countries.



The Yale School of Medicine; entrance, Institute of Human Relations. (Yale University News Bureau.)

*December, 1949*

# New Instrument

## CLOSED ANASTOMOSIS BY THE YOUNG CLAMP AFTER COLON RESECTION

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**D**URING the past two decades there has been marked progress in surgery of the large bowel. The management of carcinoma in the several parts of the colon has been thoroughly reviewed by MacFee,<sup>1</sup> with a comprehensive bibliography. We wish to report a group of cases in which closed aseptic anastomosis has been used after resection of colon carcinomas and discuss certain aspects of the technic.

Progress has been due to many factors such as the applications of physiology, chemotherapy and safer anesthesia which are common to all surgery. However, special technics and instruments have played some part. The resection rate is over 80 per cent and is steadily rising. The hospital mortality of those resected should approximate 5 per cent and the percentage of five-year clinical arrests averages 50 per cent or more.

The instruments that were used for closed anastomosis played an important part in the development of safer colon surgery. We believe that the instrument we are using is important now for other reasons than those which were originally ascribed to it. In 1932 one of the authors<sup>2</sup> published details of an anastomosis clamp which is very simple and which has been in constant use ever since. (Figs. 1 to 3.) Even if we are to eliminate all possibility of infection by chemotherapy, we believe that this clamp still adds very much to the ease and safety with which an anastomosis either between large and small, or between two ends of large or of small, or even an

end-to-side anastomosis can be done. When properly used it allows the surgeon and the assistant to hold the bowel with no immediate contact by hand to keep the approximation accurate and to allow the suture material to be used with all possible fineness. It prevents a diaphragm formation. This has been proved by a careful follow-up of our cases. In a few cases in which the postmortem examination after operation allowed the area to be examined carefully, there was no diaphragm formation such as had been described and such as had made trouble in other forms of anastomosis. The fact that the bowel is held firmly by the clamps is very important because the stitches cannot be pulled too tightly. Where the two ends of the bowel are held by a basting thread suture, that anastomotic suture can easily be so tight that it will cut through the tissue when the inevitable postoperative swelling and edema adds more tension. Also, there is no basting thread to break and be left behind as has been reported altogether too often. In all of the cases in which we have used this type of clamp or in which there has been any report that has come to our knowledge, there has never been either a diaphragm formation or a leak or any difficulty which could be laid to the instrument as such. We consider it as a very important part of the armamentarium in the use of intestinal anastomosis of any type.

It seemed desirable to make a careful check of the results we have obtained by applying this method of resection with

closed anastomosis. Our records of the last 100 consecutive private patients with neoplasms of the large bowel or rectum were examined. Of these 100, all patients were hospitalized; ninety-eight of the patients were hospitalized at the Faulkner

which a colostomy was performed would now have an attempted palliative resection done.

Of the resected cases, forty-five patients had resections with anastomosis and restoration of bowel continuity. It is with these

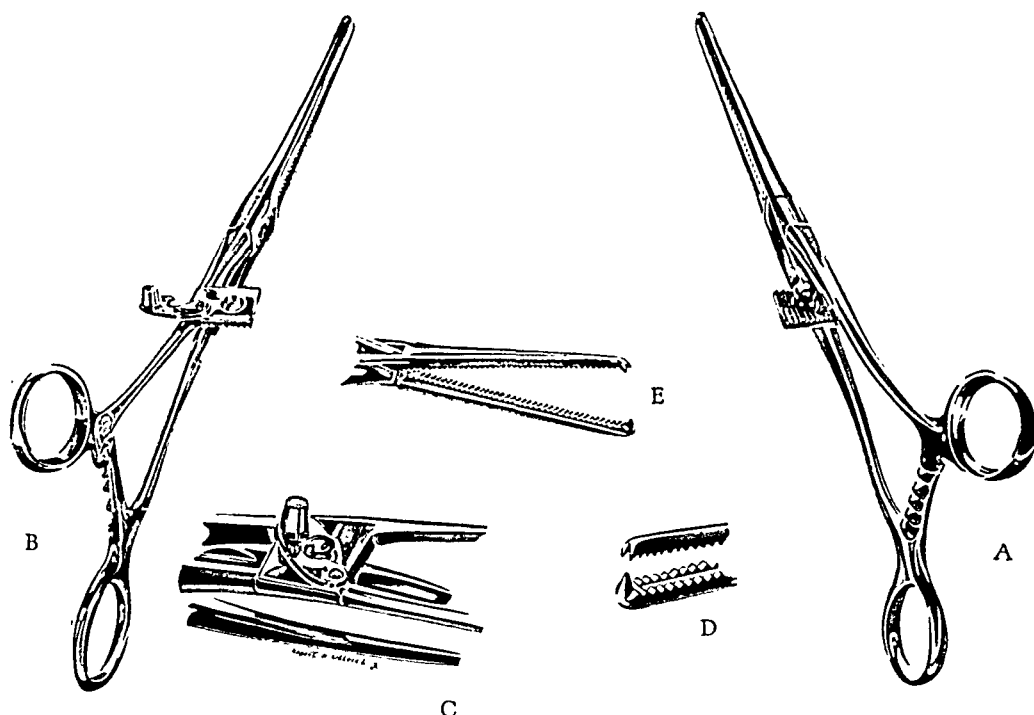


FIG. 1. Shows the two halves of the instrument in A and B with the lock open; in C it shows the simple method of locking the two together uniting the ends of the bowel in close approximation. The details of the jaws are shown in D and E because the toothed end is necessary to prevent the bowel slipping at the edge where the clamp is put in close relation to it. The central groove allows one to be sure that the clamps hold and allow the cautery to sever the bowel in an aseptic fashion close to the clamp.

Hospital. The question of operability was first investigated. It was found that ninety-six patients had undergone ninety-nine operations. Four patients were refused surgery because of advanced age and advanced degrees of growth.

The question of resectability was next investigated. Resection had been considered justifiable if there was a reasonable chance of removing grossly apparent carcinoma. Any reasonable surgical procedure should be attempted which offers the patient with obstructing carcinoma some hope of cure or more comfortable living. It was found that seventy-six resections of the primary growth had been performed on seventy-four patients. This percentage should be a little higher, we believe. Some of the earlier rectal carcinoma cases in

forty-five patients that this study is primarily concerned. The remaining patients underwent resections resulting in permanent colostomies, most of which were one-stage Miles' resections.

#### RIGHT COLON

Right colectomy has been performed in two stages in fifteen patients with carcinoma of either the right colon or hepatic flexure area. There was no hospital death in this group. Thirteen patients are living and well. Six have had an opportunity to survive more than five years and all six are apparently free of disease. The clamp method of anastomosis as described in the illustrations was used in thirteen cases. In one case, because of perforation of the growth into the pericolic fat with a good-





sized abscess, a Mikulicz exteriorization was done. In one case, that of an extremely tiny, elderly woman, an open anastomosis was done. In one case, done prior to these fifteen, a one-stage palliative resection in the presence of a malignant fistula follow-

but after a year slipped downhill and died of liver metastasis. He is one of the two patients now dead; his treatment might well be classed as a palliative resection. Another patient in whom there was extension through the bowel wall into the ureter

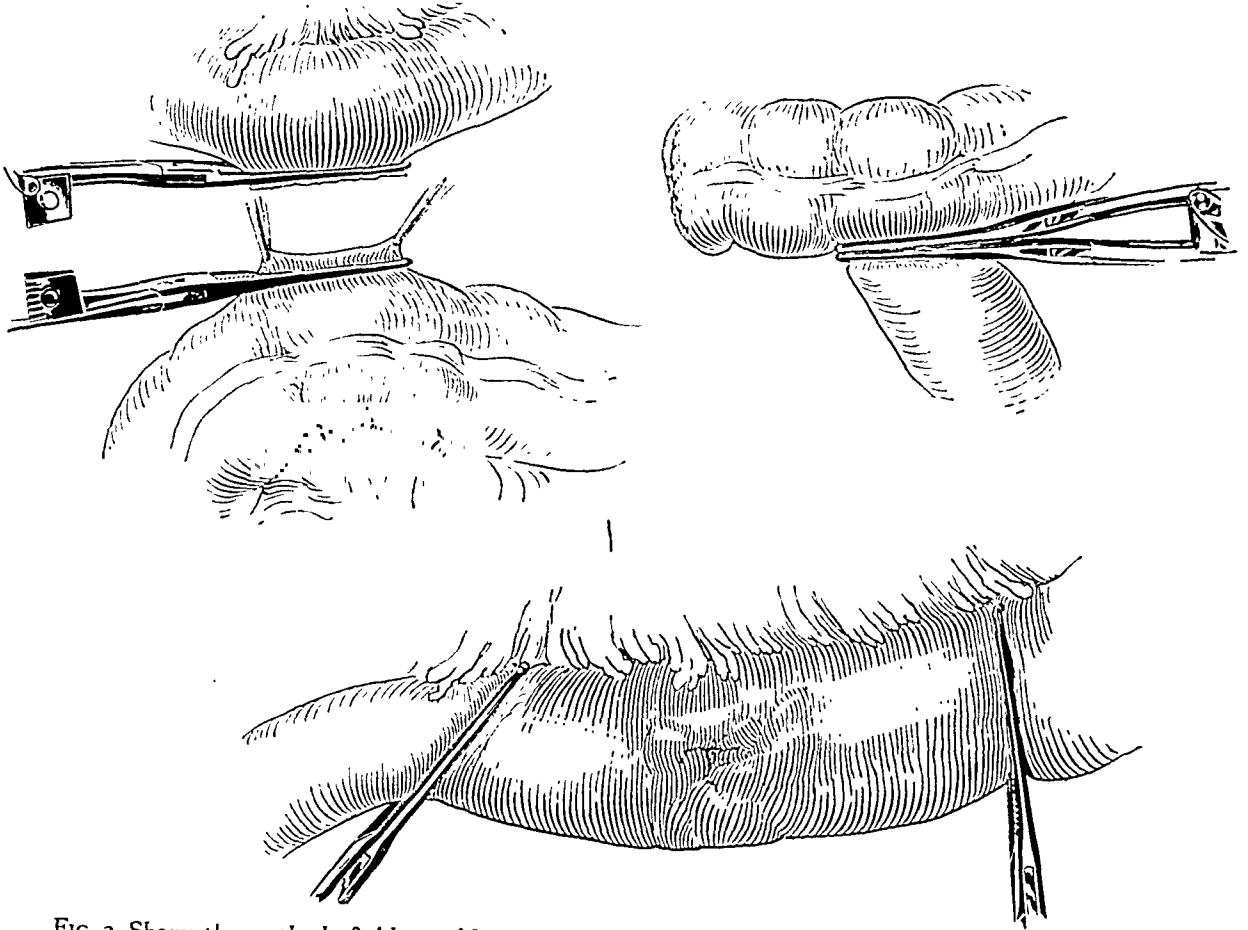


FIG. 3. Shows the method of side-to-side or end-to-side intestinal anastomosis with the same clamps.

ing rupture of a carcinoma of the cecum with abscess was attempted. This patient died of sepsis. This represents the only mortality in the right colon group. Only two patients have died of disease. We repeat that the remaining thirteen are living, well and free of disease and that there are six who have had an opportunity to survive more than five years. Of the extensive resections which were done in this group, two are worthy of comment. One man had infiltration and involvement on the serous surface of his small bowel and had a resection of 3 feet of his small bowel with a right colectomy. This man gained 40 pounds and had very good palliation

and retroperitoneal tissue of a grade iv growth with small pericecal abscesses had an extensive resection involving the parietal abdominal wall and a segment of ureter. This patient is well and free of disease seven years after operation.

#### LEFT COLON

In this group of cases in which the growth involved the splenic flexure, left or sigmoid colon and upper rectosigmoid there was a total of thirty resections in which a primary end-to-end anastomosis was performed. In this group there were two hospital deaths. The first death occurred very suddenly in the case of a

seventy-five year old man after the abdominal incision had been made prior to starting the resection of his growth at the splenic flexure. However, some traction had been exerted on the bowel in which the growth was located, which might have contributed to his sudden demise; aside from this it was considered an anesthetic death. This case was accepted by the medical examiner and there was no hospital autopsy. The other death occurred in the case of a seventy-nine year old man with a large carcinoma of the transverse colon. This patient remained in very poor general condition after his cecostomy. Resection was postponed for thirty-eight days. At the time of resection considerable plastic peritonitis was found. This patient died one day postoperatively. At autopsy there was no evidence of any leak at the suture line. In four cases resection was performed in the presence of small hepatic nodules believed on palpation to be metastatic lesions. These patients all died of malignancy in one and a half to fifteen months after their resections; their treatment should be separately grouped as palliative resections.

Of seventeen patients who have had an opportunity to survive more than five years, there are five now living and well, free of disease. Eight patients have died of malignancy, four are untraced for the full five-year period but three of these were known to be well for shorter periods than five years. In regard to those patients who have survived for a shorter time than five years, five are now living and well, apparently free of disease, one has died of cancer and another of causes other than cancer.

Anastomosis was done by the closed clamp technic in twenty-nine of the thirty

resections. In three cases anastomoses were made below the pelvic floor between the upper rectal ampulla and the sigmoid; it was in one of these that the open method was used.

These figures are presented merely in evidence that there had been no delayed stricture formation and that a reasonably wide excision was made by the clamp technic as evidenced by the adequate number of patients cured of their disease. In summary, the closed clamp method as described was used in forty-two anastomoses after resection for colon carcinoma. The hospital deaths are outlined briefly. The end results seem adequate; no strictures or leaks have occurred. The clinical arrests are above the average in the right colon group and slightly below the commonly reported average in the left colon group. We believe that the better results in the carcinomas of the right colon may be attributed to the better removal of regional lymph nodes possible on this side. Attention should be paid to a more radical lymph node removal when resecting carcinomas from the descending colon and sigmoid colon.

#### CONCLUSION

Closed anastomosis with the Young clamp by the method described has proven safe and advantageous when restoration of continuity can be performed after resection of carcinoma of the colon.

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